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ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER--ETC(U)
NOV 73 E T CAWLEY, W L SCHWARZ, C W RUDELIUS DACW37-73-C-0059

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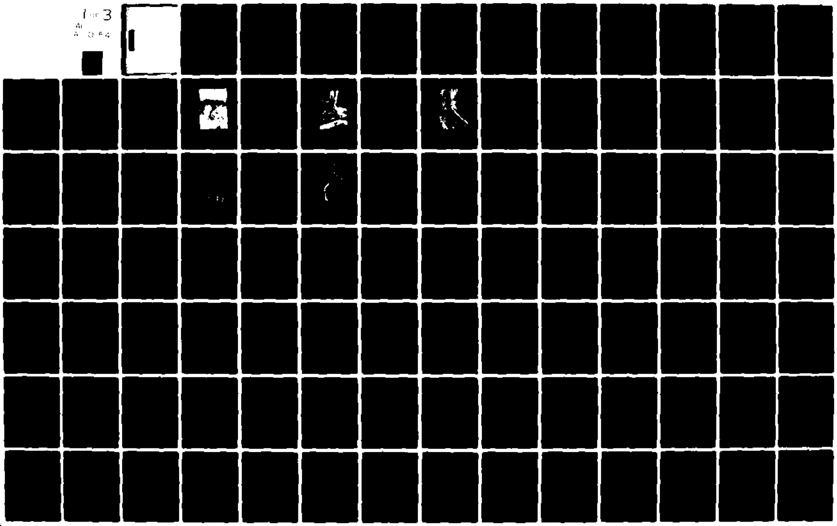

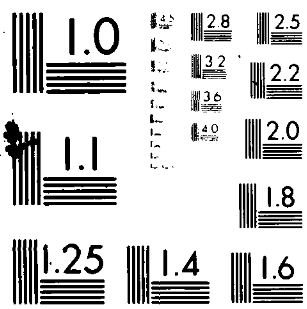

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A110 154	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER MISSISSIPPI RIVER, POOL 10.		5. TYPE OF REPORT & PERIOD COVERED Final report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Edward T. Cawley, W.L.K. Schwarz, C.W. Rudelius, Barbara J.R. Gudmunson		8. CONTRACT OR GRANT NUMBER(s) DACW37-73-C-0059
9. PERFORMING ORGANIZATION NAME AND ADDRESS North Star Research Institute, Environmental Services Division, 3100 38th Ave S., Minneapolis, MN 55406		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Army Engineer District, St. Paul, Corps of Engineers, 1135 USPO & Custom House, St. Paul, MN 55101		12. REPORT DATE November 1973
		13. NUMBER OF PAGES 200
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Barges
Inland waterways
Navigation
Environmental assessment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The overall objectives of this reports are to assess the impacts, both positive and negative, of the Corps of Engineers' activities on Pool 10 (Guttenberg, Iowa) on the Mississippi River. The report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life, geology and water quality. Socioeconomic systems include industrial and recreational activites, and cultural considerations, which include archaeological and historic sites.

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FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT STUDY

POOL 10

of the Northern Section of the
UPPER MISSISSIPPI RIVER

for the

ST. PAUL DISTRICT CORPS OF ENGINEERS
Under Contract No. DACW37-73-C-0059

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ENVIRONMENTAL IMPACT STUDY OF POOL 10
OF THE NORTHERN SECTION OF THE UPPER
MISSISSIPPI RIVER

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Purpose of the Environmental Studies

The National Environmental Policy Act of 1969 directs that all agencies of the Federal Government "include in every report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement ... on the environmental impact of the proposed action." The Act deals only with proposed action. However, in keeping with the spirit of the Act, the U.S. Army Corps of Engineers has developed its own policy that requires such reports on projects it has completed and for which continuing operational and maintenance support are required.

In keeping with its policy, on January 15, 1973, the St. Paul District of the U.S. Army Corps of Engineers contracted with the North Star Research and Development Institutue to prepare an environmental impact assessment report of the Corps of Engineers operating facilities and operations on the Mississippi River from the head of navigation in Minneapolis, Minnesota, to Guttenberg, Iowa. Included also are the Minnesota and St. Croix Rivers from the heads of navigation at Shakopee and Stillwater, Minnesota, respectively, to the Mississippi River. This portion of the Mississippi River basin will subsequently be termed the "Northern Section" of the upper Mississippi River, the "study area", or the St. Paul District.

The Corps of Engineers has been active in the Northern Section since the 1820's when they removed brush and snags from the river to permit

navigation as far north as Fort Snelling. Later in the 1870s, further improvements were made, primarily through construction of wing dams, to deepen and maintain the channel. Presently, the study area of the river consists of a series of pools, which were created by the construction of navigation locks and dams in the 1930's. Several recreation areas along the river were also built by the Corps.

The purpose of the environmental impact study is to assess the impacts, both positive and negative, of the Corps' activities on the Northern Section. These activities are defined as operations and maintenance activities and mainly include operations of facilities (locks and dams) and maintenance of the navigation channel (dredging). Some activity also concerns recreation areas. Actually, the impacts on the environment of the earliest operations are also being sought, but most of the information will concern those of the present navigation system.

The studies are designated to identify the impacts and to assess their effects on both the natural and social environment. Such impacts may include effects of river transportation on the area economy, effect of creation of the pools on recreational activities and wildlife habitat, effect of dredge spoil disposal on the natural ecosystem and on recreation, and many others. As a result of identification and assessment of the impacts, it may be possible to suggest ways of operating the facilities and maintaining the navigation and recreation system to amplify the positive and minimize the negative results of the Corps' activities. The study will provide a comprehensive basis for the St. Paul District to

prepare an environmental impact statement consistent with the National Environmental Policy Act of 1969 and the policy of the U.S. Army Corps of Engineers.

Research Approach

Three aspects of the research used in the study deserve clarification: (1) the benchmark point in time, (2) data collection and analysis on the natural systems, and (3) data collection and analysis on the socioeconomic activities.

Benchmark Clarification

In order to analyze the impact of the activities of the Corps of Engineers on the Northern Section of the Upper Mississippi River, it is necessary to select a time period that can serve as a benchmark. This benchmark represents the state of the Mississippi River prior to the time activities related to the nine-foot channel were initiated. As the nine-foot channel project was constructed in the 1930's, the preconstruction benchmark was taken as 1930. Wing-dams were built and other Corps' activities took place prior to 1930, however, and earlier data were also used where they were readily available. The preconstruction benchmark data were obtained from available reports and from a variety of other sources.

Analysis of the Natural Systems

The impacts of Corps' activity on the natural environment for a given pool were determined by the individual investigator responsible

for that particular pool. The Northern Section of the upper Mississippi River was subdivided into fourteen distinct segments for purposes of study of the natural environment: Pools 1 through 10, Pool 5A (lying between Pools 5 and 6), the Upper and Lower Saint Anthony Falls (SAF) Pools (a single report covers both pools), the Minnesota River, and the St. Croix River. Segments were assigned to investigators on the natural science team. The responsibilities are listed below:

Number of River Segments Involved	River Segment	Responsibility
5	Upper and Lower SAF Pools, Pool 1, Pool 2, Minnesota River, and St. Croix River	[illegible], North Star Research and Development Institute, Minneapolis, Minnesota
1	Pool 3	[illegible], St. Mary's College, Winona, Minnesota
4	Pools 4, 5, 5A, & 6	Calvin Fremling, Winona State College, Winona, Minnesota
2	Pools 7 & 8	Thomas Claflin, University of Wisconsin, La Crosse, Wisconsin
1	Pool 9	[illegible], Luther College, Decorah, Iowa
1	Pool 10	Edward Cawley, Loras College, Dubuque, Iowa

Because different problems arise in different segments of the river, each investigating team used its own judgment in conducting its studies.

However, North Star--in conjunction with the investigators cited above--developed general guidelines for conducting the field studies, acquiring data, and presenting the data in a final report. This required that North Star develop a format that could be used for all pool reports so that the series of reports would have maximum utility and comparability.

Analysis of Socio-economic Activities

The socio-economic analysis for all pools in the study area was conducted by a team including Dr. [illegible] of the University of Minnesota and Mr. [illegible] of North Star. The socio-economic impacts were analyzed by the same team for all fourteen segments of the Northern Section because substantial economies in data collection were possible with this approach. The initial data for each pool were collected and then were submitted for review and updating to the investigator analyzing the natural systems for that pool. The suggestions of these investigators were incorporated in the socio-economic portions of each pool report.

Report Objectives

The Corps is required to submit a statement for each pool and tributary in the Northern Section of which they carry out operation and maintenance activities; thus, as far as is practical the study was carried out by pools.

The present report deals only with Pool [illegible] on the upper Mississippi River, which is described in detail in subsequent pages. Other reports in this series deal with the other pools and the tributaries comprising

the Northern Section of the upper Mississippi River. Background information that applies to two or more pools in the study area appears as a portion of each appropriate report. This is necessary since the report on each pool must be capable of being read and understood by readers who are interested only in a single pool.

The overall objectives of this report are to identify and provide an assessment of the impacts of the Corps of Engineers activities related to Pool 10. Specifically, following this section, the report is in the format required for the Environmental Impact Statement, and seeks:

1. To identify the environmental, social, and economic impacts of the Corps activities related to Pool 10.
2. To identify and, where possible, measure the beneficial contributions and detrimental aspects of these impacts and draw overall conclusions about the net effects of Corps' activities.
3. To recommend actions and possible alternative methods of operations that should be taken by the Corps of Engineers, other public agencies, and private groups to reduce detrimental aspects of the project.
4. To identify additional specific research needs to assess the impacts and increase the net benefits of Corps operations.

The report includes an analysis of natural and socioeconomic systems. The natural systems include terrestrial and aquatic plant and animal life as well as the nature of the land and quality of the water.

Socioeconomic systems include industrial activities, such as income and employment generated by barge traffic or activities in operating the locks and dams; recreational activities, such as fishing, boating, or hunting that are related to Corps operations; and cultural considerations, which include archaeological and historical sites.

1. PROJECT DESCRIPTION

The project consists of structures and operations and maintenance activities. The structures include 1) 104 wing dams, 7.8 miles of bank revetments, and 13 closing dams, built mostly between 1878 and 1910; 2) Lock and Dam No. 10, consisting of a main lock and the upper gate bay of an auxiliary lock, a movable dam section, an earth dike and an ogee spillway.

Operation include lock operations and dam operations.

Maintenance includes dredging the navigation channel and harbors to a minimum nine-foot depth, disposing of the dredge spoil, clearing debris from the channel area, and maintaining the locks and dam.

AUTHORIZATION

The nine-foot channel project was authorized on July 3, 1930 with the passage of an act by the Seventy-first Congress which modified the existing six-foot channel project in accordance with a comprehensive plan to develop a nine-foot channel submitted in House Document No. 290. A series of amendments in 1935 and 1937 extended the project above the St. Anthony Falls, and to the Missouri river. There have been several additional acts since that time to construct harbors, and flood walls in Pool 10.

HISTORY

The original form of the Mississippi river was a shifting, highly divided relatively shallow braided river flowing in the broad flood plain

deposited by the outwash drainage of Wisconsin glaciation. The extensive Development of islands, mud flats, and sand bars formed an interlacing network of chutes, sloughs, and channels.

Navigation was hindered by the shifting channels and extensive areas of snags, large trees left in the channel by receeding flood waters.

As early as 1824 appropriations of the Federal Government financed snagging operations from the Missouri river to New Orleans. In 1878 Congress authorized the development of a 4½ foot channel from St. Paul, Minnesota to the mouth of the Ohio River. In 1907 a new project was authorized to increase this to a six-foot channel. The project was developed by the construction of hundreds of wing dams, formed of alternate layers of rocks and brush, projecting into the channel from the shore to constrict the flow and increase the scouring action of the water. Bank revetments were installed to prevent bank erosion. Closing dams were also constructed to augment flow in the main channel by reducing the flow into the side channels and sloughs. (Fig. 1)

Location

With the continued expansion of navigation, the Seventy-first Congress authorized the nine-foot channel project. The nine-foot channel was achieved by the construction of locks and dams supplemented by dredging. The present Lock and Dam 10 is located 651.1 river miles above the mouth of the Ohio River, and 32.8 river miles below Lock and Dam No. 9. The lock is on the right bank (Iowa side) of the Mississippi River adjacent to the

Figure 1. Copy of 1929 Aerial Photo showing wingdams and revetment in Pool 10.

town of Guttenberg which is at the southern most limit of the St. Paul District. Construction began on 11 February 1934 and was completed on 15 December 1936. Lock and Dam No. 10 was placed in operation on 26 November 1937 by the Rock Island District, and on 1 October 1939 control of the project was transfered to the St. Paul District. (Regulation Manual, 1972) In the section of the Mississippi River presently known as Pool 10-Mile 615.1 to 647.9 the wing dams and closing dams are presently submerged and their location may be located on the current navigation charts.

The changes in the reach of the river now known as Pool 10 may be noted on a series of charts (Fig. 2, 3, 4, 5) showing the various stages of development from the 4.5 channel in the 1890's, to the "Brown Survey" in 1930. These were reissued as the "Flowage Charts" in 1933-34 to indicate land ownership for use in the acquisition program of the nine-foot channel. The"Flowage Charts" only cover the portion of Pool 10 from the mouth of the Wisconsin River to Guttenberg, Iowa. In 1938 the Corps published charts of the nine-foot channel, the "Continous Survey", showing river soundings and sand bars. Several editions followed, the most recent, 1972, are based on a 1964 aerial survey. There are no contours between the Wisconsin river and Lock and Dam 9 on these maps of pool 10. There are also the "Upper Mississippi River Navigation Charts" for general boating useage.

CORPS FACILITIES

Lock and Dam No. 10 consists of a main lock 110 feet wide and 600 feet long, the upper gate bay of an auxiliary lock, and a movable dam

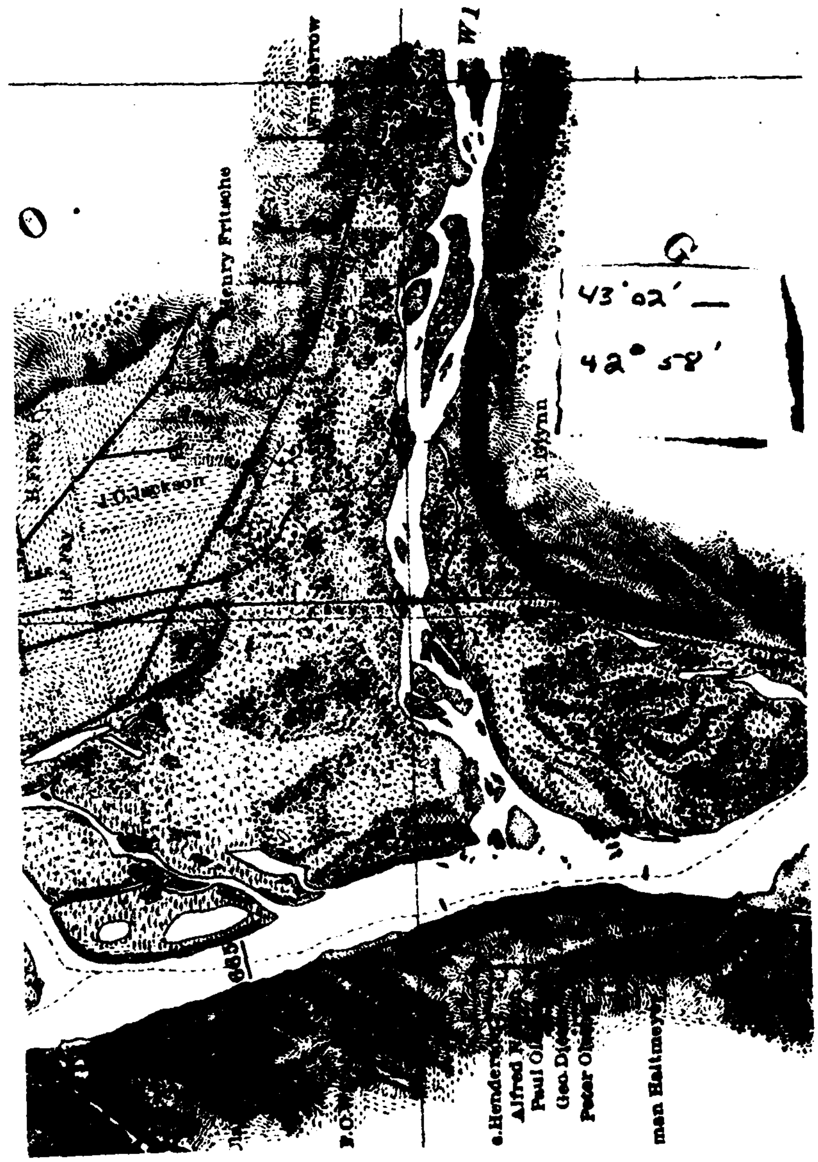

Figure 2. 1890 map at Pool 10. showing mouth of the Wisconsin River.

Figure 3. Map of Pool 10 from Brown Survey at 1930's
showing same area as fig. 2.

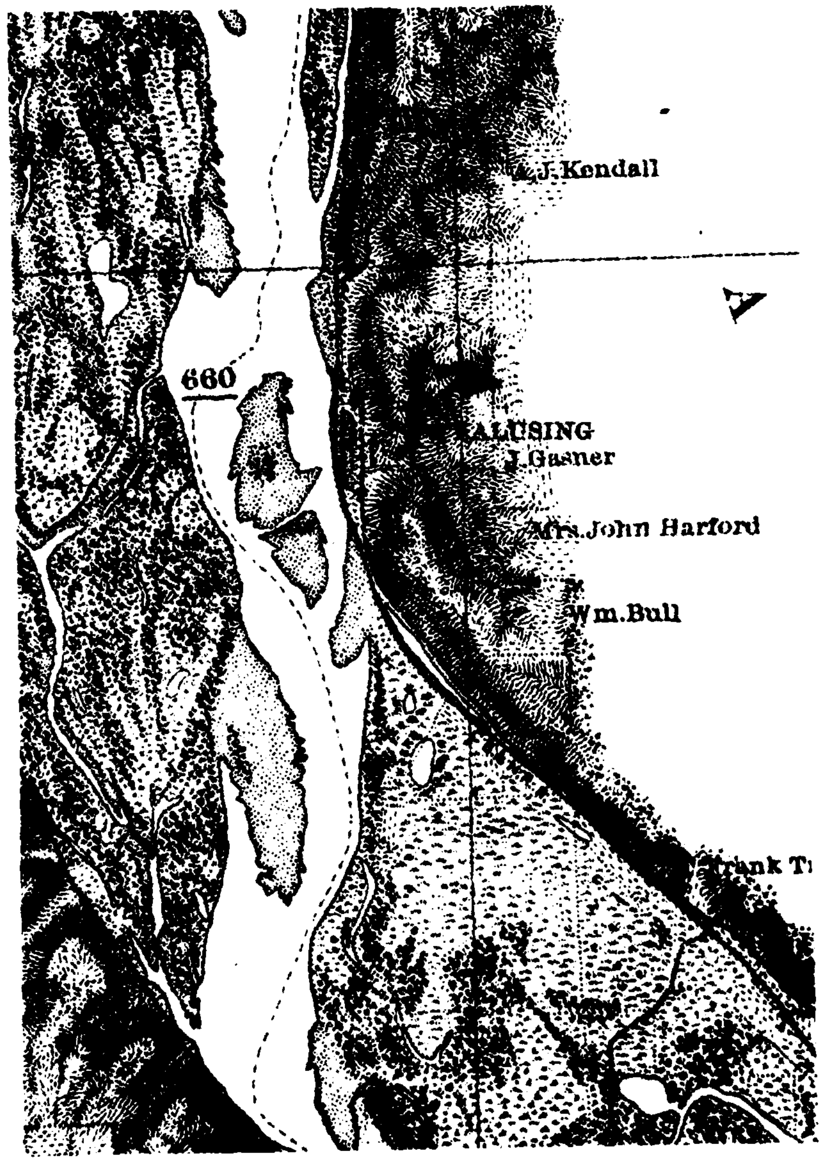

Figure 4. 1890 Map of Pool 10 just south of section in figure 2.

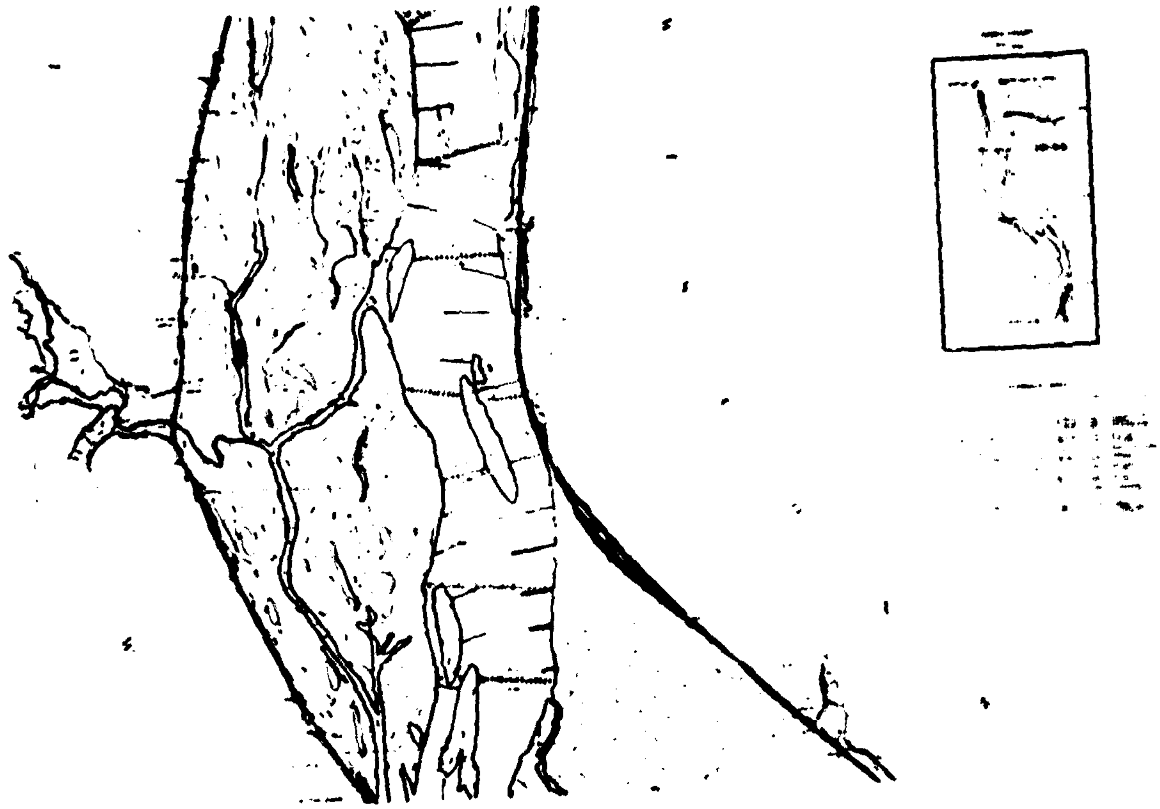

Figure 5. Brown Survey Map of Pool 10 of same area as figure 4.

section consisting of four roller gates and eight tainter gates extending across the main channel to the left bank of the river. An earth dike, 4,547 feet in length is placed from the end of the movable dam to the embankment of the CB&Q RR on the Wisconsin side of the river, with a fixed crest, concrete, ogee spillway, 1,200 feet in length at the head of Cassville Slough. (Fig. 6)

BASIC PLAN OF OPERATION

The plan of operation for Lock and Dam No. 10 was originated by the Rock Island District and differs from the normal plan of operation of the projects in the St. Paul District as detailed in Paragraph D-15 of "The Master Regulation Manual". The primary control point is at Lock and Dam No. 10 instead of at the point of intersection of project pool elevation with the ordinary high water profile.

Primary control consists of maintaining project pool, Elevation 611.0, at the dam by the operation of the movable gates at Dam No. 10 until the stage at Clayton reaches 9.2 feet at a flow of 42,000 cfs. Clayton then becomes the secondary control point, and regulation of the pool is shifted to secondary control, which consists of maintaining the stage at Clayton at 9.2 feet as the flow exceeds 42,000 cfs. (Fig. 6_a)

As the discharge approaches 52,000 cfs, the pool at the dam will be lowered to the maximum allowable drawdown, one foot, to elevation 610.0, and at this stage Lock and Dam No. 10 again becomes the control point with teritiary control being put into effect. The latter control consists of holding the pool at the dam at elevation 610.0 until the discharge

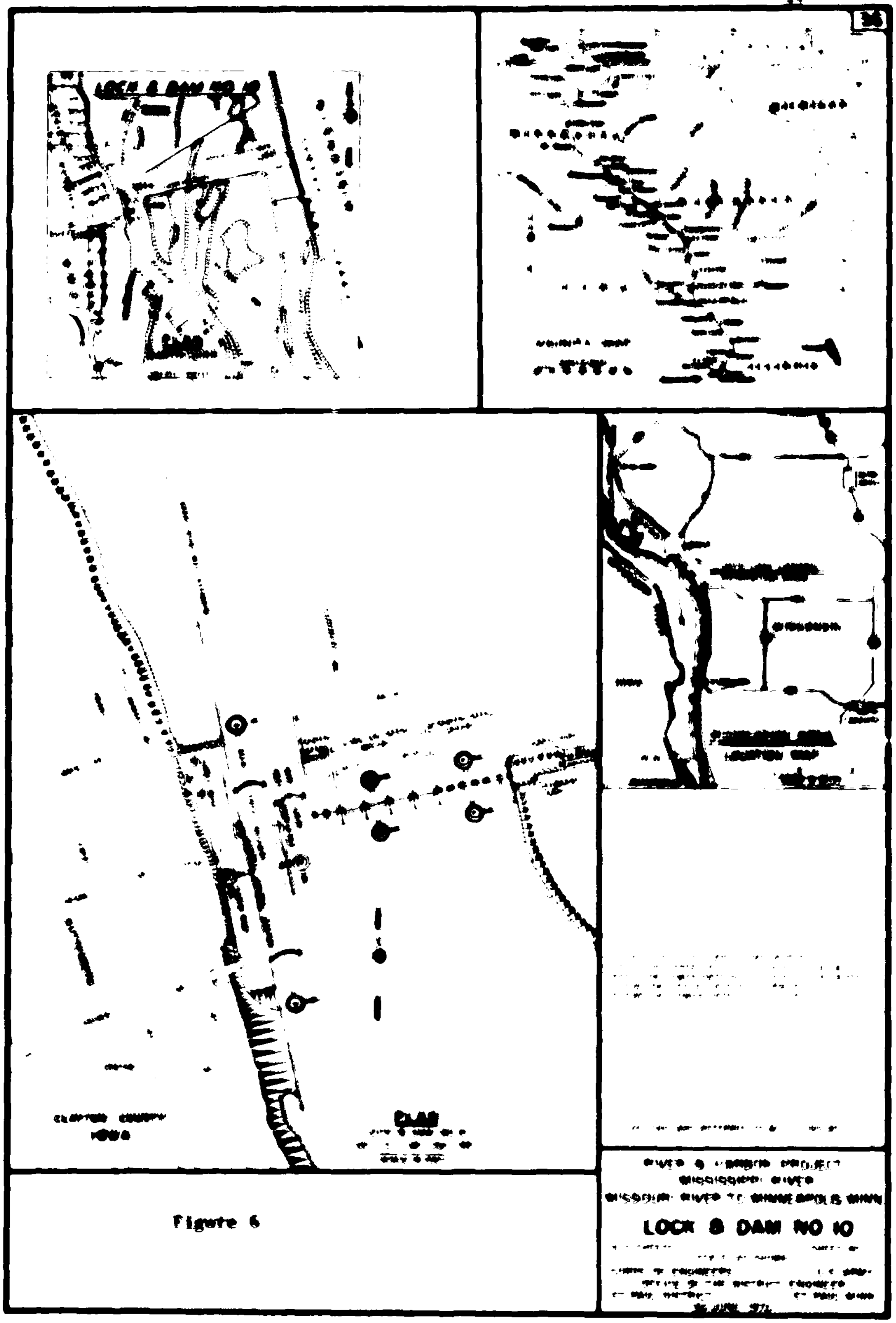

Figure 6

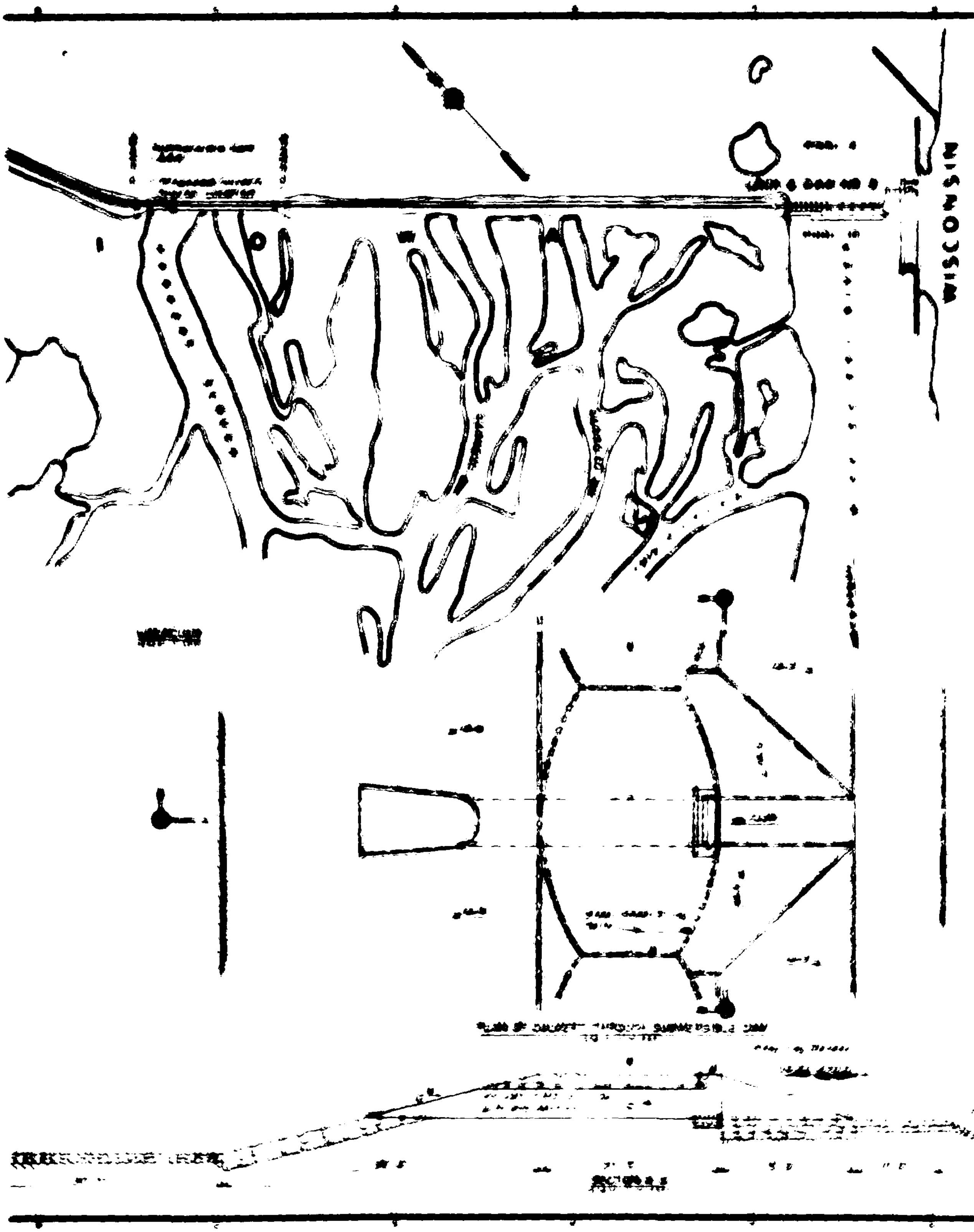

Figure 6, Culvert through submersible dam

approaches 70,000 cfs, and the head at the dam is reduced to just a small head of one foot or less. When this reduction in head occurs, all the movable gates in the dam are raised clear of the water to their maximum elevation. Dam No. 11 is out of control, and open river conditions are in effect. As flow decreases the above operation is reversed.

Flow rates used in determining [illegible] operations are determined by discharge rates of Dam No. [illegible], the [illegible] flow at [illegible], and the [illegible] River flow at [illegible].

The use of this system of pool regulation [illegible] to the region south of the mouth of the [illegible] River. This reduced the cost of acquiring flowage rights, since only [illegible] acres of land were involved in the [illegible] of the pool operation.

[illegible]

In [illegible] the [illegible] through the [illegible] to the [illegible] Slough south of Dam No. 11 [illegible] of the [illegible] (Fig. 4).

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Jacobs, W. No date. The First One Hundred Years. A history of Guttenberg, Iowa. Guttenberg Press, Guttenberg, Iowa.

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2. ENVIRONMENTAL SETTING

INTRODUCTION

The environmental setting of the project covered in this section includes a description of the study area from the period prior to the authorization of the nine-foot channel (1930) up to the present time. Because the project under consideration was initiated about 40 years ago, it is difficult to reconstruct accurately the natural and socioeconomic setting prior to lock and dam construction. There are three reasons for this difficulty:

1) lack of precise data on the environmental setting prior to 1930;

2) the difficulty in isolating some changes in the river environment due to the nine-foot channel from those caused by the earlier 4-1/2- and 6-foot channels or by increased population and industrialization along the river; and,

3) the practical emphasis on reducing the environmental impact of operating and maintaining the nine-foot channel assuming its continuation -- not eliminating it entirely.

Therefore, the descriptions of the pre-project environmental settings in this section were reconstructed from available published information and are of necessity brief and not complete.

In the discussion of the environmental impact of the project later in Section 3 an attempt has been made to identify changes in the study area

occurring in the past four decades that are attributable to the nine-foot channel project.

NATURAL SETTING

The Mississippi River basin has been modified by man since the early 1800's. Reconstruction of conditions before this time is difficult and of limited value since this project is primarily concerned with the effect since the Lock and Dam construction in the 1930's. This overview of the natural setting will attempt to develop an idea of the 1930 condition in Pool 10 with some recognition of the earlier effects of man.

From its source at Lake Itasca downstream to Lock and Dam No. 10, the Mississippi River and its tributaries drain a watershed of 79,370 sq. miles. Of this total 12, 760 sq. miles of watershed contributes to the tributaries entering Pool 10. The only major tributary is the Wisconsin River, the second largest tributary in the St. Paul District (11,700 sq. miles of watershed).

Geology

The area surrounding Pool 10 is an upland formed by two cuestas, upland belts with a short, steep descent or escarpment on one side and a long gentle slope on the other. This formation is formed by alternate layers of resistant and weak rock dipping parallel to the gentle slope. The cuesta north of the Wisconsin River is composed of Lower Magnesian (Prairie du Chien) limestone formation which dips below the cuesta south of the Wisconsin River formed of the Galena-Black River (Galena-Platteville) limestone formation. The area is underlain with Cambrian sandstone. (Martin, 1932)

Driftless Area

The "driftless area" which includes most of southwest Wisconsin and portions of Iowa and Minnesota (Fig. 7) is a region which was by-passed by the southward extension of the glacial lobes during the Pleistocene. Recent evidence has indicated the presence of Kansan glacial till along the Iowa side of the Mississippi, and there is some discussion of the possibility of some early till from Nebraskan glaciation in Wisconsin, but if present its majority has been removed by weathering processes. (Hartley, 1966). The effects of glaciation, the leveling of the land by ice action and the deposition of glacial till, are not present in the driftless area and weathering has occured to a greater extent than in the surrounding areas.

Topography

Uplands

The result of the geologic formations and the long period of weathering has resulted in a highly disected upland with numerous steep bluffs, craigs and pinnacles, and natural bridges. Solution activity in the limestone has resulted in extensive areas of sink holes and caves, not found in the areas of glacier drift. (Martin, 1932)

Mississippi River Gorge

Within the Upper Mississippi Valley the Mississippi River flows in a channel contained within a gorge or youthful steep sided trench which follows the western border of Wisconsin. At Prairie du Chien, at the middle of Pool 10, the gorge is 2½ miles wide and 500 feet deep. The

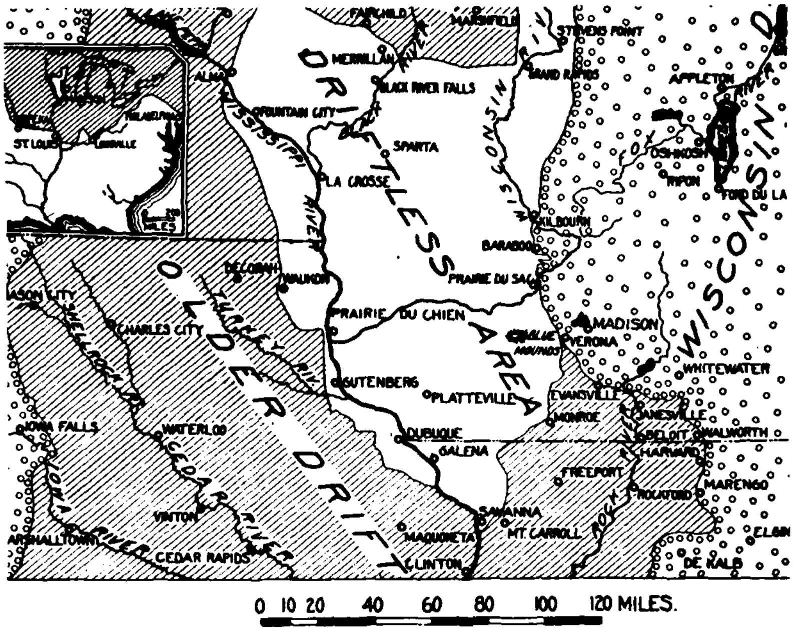


Figure 7. Driftless area (From Martin 1932)

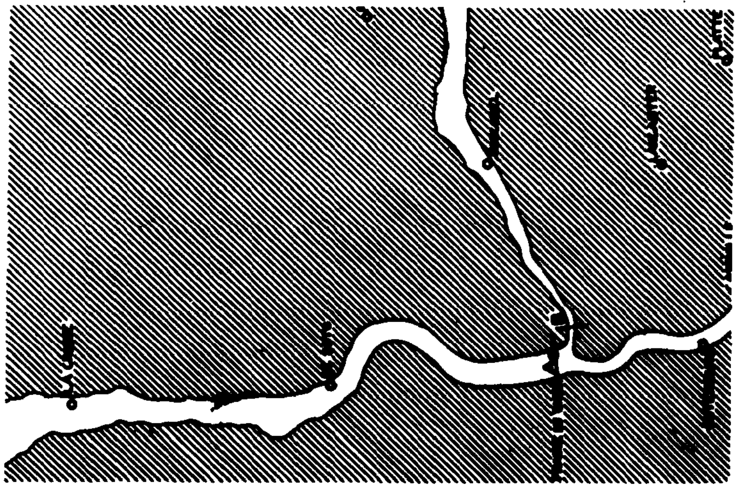


Figure 8. The constriction of the gorge of the Mississippi River at the mouth of the Wisconsin River (From Martin, 1932)

gorge widens to the north to 3 miles or more as a result of down cutting into the weaker Cambrian sand stones. The downward dip of the resistant Lower Magnesian limestone just south of Prairie du Chien causes a narrowing of the gorge to 1½ just below Guttenberg. Fig. 8. The gorge consists not of extensive palisades but is deeply disected and forms a series of steep bluffs broken by narrow ravines formed by the small tributary streams. The gorge has a youthful appearance but the bottom land and the channel have a mature appearance.

There are a number of narrow terraces, rising about 25 feet above the flood plain. The major ones in Pool 10 are at Prairie du Chien, Bagley, and Guttenberg. (Fig. 9) The floodplain occupies most of the bottomland and has a very shallow grade, .01% per mile.

The floodplain material is clay, silt and loam intermixed with sand. The floodplain is underlain with 150 feet of outwash till deposited by the river at the time of glacial recession.

The floodplain contains not only the main channel, which occasionally is divided into two almost equal channels as seen at Prairie du Chien, but also many narrow sloughs. Some of these are outlets of tributaries but most are more closely related to bottomland lakes which are abundant in the broader reaches of the gorge. Most of these lakes are small and form behind the natural levees which form raised elongated ridges along both sides of the channel.

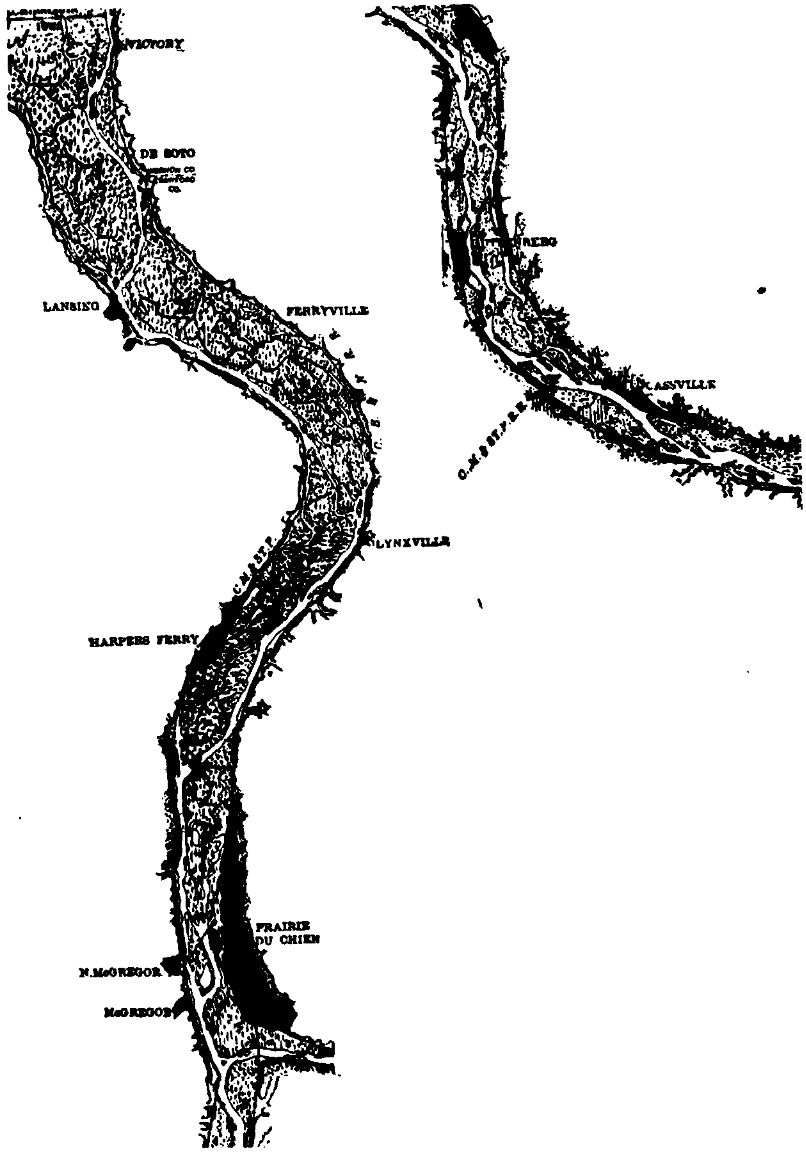


Figure 9. Terraces located in the Valley in Pool 10
(From Martin 1932)

Wisconsin Delta

While the Wisconsin River carries a sediment load 30% greater than the Chippewa (U.S. Army C. of Eng., 1970) its delta has not resulted in the damming effect which developed Lake Pepin.

Just above the confluence of the Wisconsin with the Mississippi the Lower Magnesian limestone dips below the surface. This resistant formation restricted the gorge erosion and resulted in a narrowing of both the Wisconsin, and the Mississippi channels. The resultant increase in velocity of the Mississippi allowed the majority of suspended materials to be carried down stream, rather than developing a delta. This narrowing of the channel reaches its maximum at Clayton, Iowa, where the river is constricted to 725 feet as compared to 1400 at Prairie du Chien. This reach of the river is also the deepest stretch, 37 feet on the 1893 charts, south of Lake Pepin. (Martin, 1932)

Scenic Aspect

This combination of factors has resulted in this section of the "driftless area" being recognized as one of the most scenic areas in the Mid-west. As early as 1854 Wisconsin's first state geologist, Edward Daniels, (1854) described the area: "About one-third of the surface is prairie, dotted and belted with beautiful groves and oak openings. The scenery combines every element of beauty and grandeur - giving us the sunlit prairie, with its soft swell, waving grass and thousand flowers, the somber depths of primeval forests; and castellated cliffs, rising

hundreds of feet, with beetling crags which a Titan might have piled for his fortress."

Topographic Modification by Man

The early activity to improve navigation was limited to snaging operations and some localized dredging which had little major effect on the overall topography of the pool. The approval of the six-foot channel project with the resultant placement of closing dams and wing dams caused the first major changes in the river. The wing dams caused a narrowing and deepening of the channel, but also increased deposition of sediments in the slack water areas below the wing dams. The formation of these lateral bars can be noted in miles 628 and 645 of Pool 10. The closing dams, by diverting water into the main channel, increased stagnation of the sloughs and river bottom lakes, and increased the impact of low water in the summer on these flood plain areas. (Carlander, 1954)

Climate

The general climate of Pool 10 is Continental with very cold winters and rather hot summers. The Mississippi river has a moderating effect, resulting in warmer temperatures and longer growing seasons. Comparing temperatures at Prairie du Chien with those at Postville; about 30 miles west in Allamakee County, we find the average January temperature at Prairie du Chien, 17.6^{o}, is 1.4^{o} higher than at Postville. The July average 73.7^{o} is 1.9^{o} higher, and the growing season at Prairie du Chien is 166 days compared to 151 days at Postville. The average annual precipation in the area is 32.48 inches, with about 22 inches coming in the

growing season, (USDA, 1941). The combination of long growing seasons, high humidity and abundant soil moisture produce semitropical growing conditions in the bottomlands during the summer.

Soils

While there are extensive classification of the detailed soil types in this area (Hole and Lee, 1955, Calvin, 1895, Leonard, 1906) only a general descriptive account will be given here. Most of the upland soils are developed from "loess". A wind blown material from the outwash sediments released during Wisconsin glaciation (Ruhe, 1972). The specific soil type depended upon the vegetation developing on the loess deposits, and varied from deep rich loam under prairie or maple woodlands to leached podzolic soils under the oak-hickory woodlands.

The soils on the steep bluff sides that did not retain the loess cap, developed from weathered limestone or sandstone. The north and east slopes, covered with mesic maple forests, developed a rich loamy soil; and the south and west facing slopes with "goat prairies" or cedar glades developed a clay loam which is thin as a result of erosion from runoff from the steep slopes.

The bottomlands have diverse soils of alluvial origin. Most of the bottomland soils are composed of layers or lenses of sand, clays and silts deposited following the periodic flooding. In the areas of annual flooding there is little soil development since humus material is removed or covered annually. The higher lands on the natural levees or the ter-

races may develop an A layer. A gley layer (Wilde, 1940) of sticky fine clay with blue-green motling from reduced iron is present in all bottom-land soils. It indicates poor internal drainage and anaerobic soil conditions.

Some of the high terraces, i.e. Prairie du Chien, have sandy loam soils which developed under prairie vegetation.

Hydrology

The average stream flow at the McGregor, Iowa gaging station is 3[illegible] with a maximum 2[illegible] cfs. and a minimum 6,[illegible] cfs. The flow of the Wisconsin river at Muscoda, Wisconsin is 8,48[illegible] cfs with a maximum of 80,800 cfs and a minimum of 2,000 cfs. While low flows are at times a problem above Prairie du Chien, 6[illegible] cfs at St. Paul and 3,2[illegible] cfs at Winona, the river is less prone to low flow below the confluence of the Wisconsin since the normally high base flow of the Wisconsin is augmented by storage in the hydroelectric power system upstream. (U.S. Army C. of Engin. 1970)

Fluvial Sediments

The watershed draining directly into Pool 10 belongs to the "Central Feed Grains and Livestock" Land Resource Region in the Soil Conservation Services classification. It is the highest sediment producing area in the Upper Mississippi River Basin (U.M.R.C.B.S., 1970). The sediment yield of the Mississippi river at Clayton, Iowa is [illegible] tons/sq.mi./yr. or 3,247,200 tons a year, over twice as much as is carried at Lock and Dam [illegible] tons/sq.mi./yr. or 1,570,000 tons). The majority of this additional yield is contributed by the Wisconsin river, 2[illegible],000 tons a year, and the Kickapoo river, [illegible],000 tons a year. The Wisconsin, in its lower reaches, transports a significant load of sand as a bed load. The particle size distribution was 30% sand, 70% silt and clay ([illegible], 1970). Much of this sediment is deposited in the Mississippi in the area below the mouth of the Wisconsin either in the channel or around islands and in the back water areas. The placement of [illegible] in the early 1930's increased

the sedimentation in the side channels adjacent to the main channel down stream of the wing dams (fig. 20). The closing dams by diverting the water from the sloughs tended to keep the heavier particles in the main channel, while increasing the siltation of the finer particles in the back waters.

In the past these sediment values most likely varied in response to land use patterns, with highest values during the logging in the 1890's and the era of wheat farming. There may have been a decrease in recent times as a result of the development of the hydroelectric power reservoirs on the Wisconsin River and development of soil conservation practices on the watersheds.

Water Quality

Little is known of the water quality of the Mississippi River prior to the post 1930's. However, [illegible] (1932) [illegible] supply limited information on [illegible] the summer of 1928.

The [illegible] ranged from 14,300 per cu. meter to 17,300 per cu. meter of Copepoda and 147 per cu. meter to 80 per cu. meter of [illegible]. These values were only exceeded by the populations in Lake Pepin [illegible] stations. "Below Lake Pepin a considerable increase of plankton was observed near Trempealeau [illegible]. This part of the river apparently presents more favorable conditions for the development of plankton than any other." The plankton data was grouped into the areas below and above the Rock Island rapids but there is a [illegible] of the plankton in Pool 10.

The [illegible]

The [illegible]

In the [illegible]

While [illegible]

Figure [illegible]. New terrestrial habitat formed in Pool 10, in wing dam areas south of the Wisconsin River. Agraded areas shown in black.

[illegible] Conditions

As in almost all communities in the Pool 10 region obtain their water supplies from underground sources and as a result of the small size of the communities in the Pool 10 area there is no problem with the water quality of the river from industrial or human sewage. (U.W.Q.A. -1970)

Terrestrial Vegetation

Uplands

The original upland vegetation of the area was primarily tall grass prairie on both the Iowa and Wisconsin side. The original name of Guttenberg, Prairie du Porte, (door to the prairie) was given by the French Missionaries since the tributary valley led up to the extensive prairie on the uplands. (Jacobs) On the south and west slopes of the bluffs the prairies, "goat prairies" extended down to the bottom where they also developed on some of the high terraces. Agriculture has replaced the upland prairies and the terraces have become sites for towns, such as Prairie du Chien, but extensive stands of relatively undisturbed dry prairie can still be found on the bluff slopes.

The steep north and east facing bluff side have well developed stands of maple-basswood forest grading into oak-hickory on the dryer sites. These have remained relatively undisturbed since the steep topography has limited both grazing and cutting.

Species lists of the most common species can be found in Appendix A.

Bottomlands

Background. While Pool 10 with a length of 32.8 river miles is the second longest in the St. Paul District, and its shoreline of 110 miles is also the second largest in the district, it has less water area, 17,030 acres, than many shorter pools. This narrow, deep pool has little

marsh land but extensive forested bottomland. Due to the length of the pool, land acquisition by the Corps of Engineers was limited to the region south of Prairie du Chien and as a result the flowage survey maps, the "Brown Survey" and the "Forest Inventory Maps" (Master Plan-Pool 10) were limited to the lower ½ of the pool. With the exceptions of the general survey work of the Bureau of Sport Fishery and Wildlife and a portion of a study from the University of Wisconsin (Ware, 1956), no major work has been carried out on Pool 10. The discussion in this section will use these sources and a number of studies over broader areas (Curtis, 1959, Lindsey, 1959, Hosner & Minckler, 1963) to develop an understanding of the terrestrial vegetation.

The bottomlands are those areas which are regularly subjected to flooding but in which the water table falls to, or below, the soil surface at some time of the year. They intergrade with the aquatic communities which are covered with water for the majority of the year. The intermediate habitat, the marsh or sedge meadow is limited to 6% of total bottomland area.

Woodlands. The wooded areas can be separated into several community types: I. Willow, II. Cottonwood, III. Birch, IV. Maple, V. Elm. (Corps of Engineers, 1968) These in general correspond to those developed by Curtis (1959) with I and II included in Curtis' wet type and III, IV, and V with his wet mesic.

The dominants in the wet forest type, in order of importance are:

silver maple (Acer saccharinum), black willow (Salix nigra), cottonwood (Populus deltoides), american elm (Ulmus americana), and river birch (Betula nigra). The most common understory species are: wood nettle (Laportea canadensis), poison ivy (Rhus radican), wild grape (Vitis riporia), Leersia virginica, and woodbine (Parthenocissus vitacea).

The dominants in the wet-mesic forest type, in order of importance are: american elm (Ulmus americana), silver maple (Acer saccharinum), green ash (Fraxinus pennsylvanica), basswood (Tilia americana), and black-ash (Fraxinus nigra). The most common understory species are: woodbine (Parthenocissus vitacea), wood nettle (Laportea canadensis), touch-me-not (Impatiens biflora), Jack in the Pulpit (Arisaema triphyllum), and violet (Viola cucullata). (Curtis, 1959)

The initial invaders of the newly exposed areas like sand bars, mud flats, and disturbed sites, are black willows and cottonwood. River birch and swamp white oak are dominants in open wet ground on the up-stream side of the channel. Silver maple and american elm will invade both of these types which accounts for the overall dominance of the maple and elm. In high areas, especially the upper parts of the natural levees red oak, pin oak or basswood become locally important.

Due to the subtropical conditions in the bottomland a number of trees have extended their ranges well north of their normal ranges in the valley along the river. The major species are: Kentucky Coffeetree, (Gymnocladus dioica), honey locust (Gleditsia triacanthos), smooth buckeye

(*Aesculus glabra*), river birch (*Betula nigra*), and sycamore (*Platanus occidentalis*).

Seedling reproduction and saplings typically have low densities in these stands. Germination and seedling survival are poor as a result of the periodic flooding. However the plants that do survive and mature reach large size, silver maples, cottonwoods and swamp white oaks with a 17-20 foot circumference are not unusual. Many trees have multiple stems, a result of damage from ice and other debris in spring floods.

Understory. The ground layer species have low densities and tend to a great diversity between stands, and from year to year. The spring floods delay the germination and emergence of the understory, and often the full development of the stand is delayed until August. The prolonged high water in 1973 will produce an atypical condition since many areas were still submerged late in May, well beyond the peak blooming period of the spring flowering plants.

Lianas or climbing vines are extremely important in these stands, poison ivy, woodbine, and wild grape are most common and may form as much as 25% of the canopy. (Curtis, 1959)

Succession. There is little chance for modification of the environment by the plants in the bottomland since moisture is the most important factor, and changes depend upon topographic modification. Silver maple, and american elm can invade the wet stands of cottonwood or black willow and can then succeed themselves. Further changes in composition depend

upon increasing drainage by downcutting of the streams or building up of the land level, permitting the entrance of red oak and basswood. Originally, fire from the upland prairies would burn the marsh areas along the upland side of the channel during low water periods in the fall and invade the flood plain forests. The open stands remaining were invaded by swamp white oak and river birch. A similar situation occured with abandoned agricultural land. (Green, 1947) With cessation of fires the stands under went type succession with the entrance of bur oak, white oak, silver maple, and american elm. The linear nature of the stand tend to produce uniformity of composition in the stands along long reaches of the river.

Colonization of Open Lands. Open habitats in Pool 10 can be divided into two types: 1) well drained areas subject to flooding but dry most of the year, 2) poorly-drained areas, such as swamps and sloughs, covered by water with the exception of short periods during the dry season. (Hosner and Minckler, 1963)

The well drained area included sandbars, islands, and flats. It includes most of the newly formed land along the river channel. Willows and cottonwoods are the primary species of the pioneer stage. They usually seed in and germinate in approximately equal density. Further development depends upon subsequent moisture relations. The cottonwoods, with the development of a tap root, are better able to withstand dry conditions in the early seedling stages (Barclay, 1924): (Willow is favored by wet conditions since willows are more tolerant to saturated soil and spread by root sprouts.) Willow also has more rapid growth which favors

survival in flood condition since the seedlings will not be completely submerged. This combination of factors tends to favor willow dominance in most stands. With time, successional replacement with maples, elms, and associate species will occur.

In the poorly drained areas tree reproduction occurs mainly during periods of low water during the dry seasons. Subsequent flooding may exercise a selective effect on seedling survival. Most of the studies on this type of stand have been carried out in the south where cypress, tupelo, willow and green ash are important early colonizers. Only the latter two have range extending to Pool 10. Further development toward a wet-mesic conditions depend upon improvement in the surface drainage either by deposition of silt from flooding or by artifical drainage.

Effect of Man. The bottomlands have possibly been changed less than any other habitat in the area. There was little better use for the land. Grazing, especially where the bottomlands abuted upland meadows, limited cutting, and limited recreational development were the chief modifications brought about directly by man. The majority of commercial development was usually limited to the terraces and did not directly affect the river. The removal of prairie and the cessation of fire most likely resulted in a decrease in open marshland and an increase in wet mesic woodland but this can not be documented at present. An important indirect effect is the wide spread destruction of elm as a result of the spread of Dutch Elm Disease. Since elm is a major dominant in the bottomland forests this may have an important affect on stand composition in the future. This is an area

which requires further study. The building of the wing dams and closing dams resulted in an increase in island formation and a filing in of fringing bars expanding the terrestrial habitat.

Sedge Meadow. Of the total area of 18,600 acres of land (calculated from land between the railroad tracks which run along the first terraces), marsh, or more specifically sedge meadow, covers about 6% of the terrestrial habitat. It has not been possible to determine the extent of the marsh habitat before 1930. At the turn of the century the sedge meadow may have been more extensive as a result of prairie fires on the terraces invading the bottomland during the dry season.

Little work has been done in studying terrestrial marshes, and there are no studies on record of composition in Pool 10. The short discussion here will be based on information developed by Curtis (1959) on sedge meadows in Southern Wisconsin. The community is found in lands in which the surface is just above the water table, though at times it may be submerged. The dominant plants are sedges (*Carex spp.*) and bluejoint grass (*Calamagrostis canadensis*) with a variety of broad leaved species also present. The most common include *Anemone canadensis*, swamp milkweed, (*Asclepias incarnata*) Joe-pye weed (*Eupatorium maculatum*) and boneset (*Eupatorium perfoliatum*). The community tends to be transitional between aquatic marsh and the bottomland forest. With the cessation of fire it may develop into a Shrub-Carr community. The understory remains sedge meadow but a tall shrub cover of red osier dogwood (*Cornus stolonifera*), several of the shrub willows, button bush (*Cephalanthus occidentalis*) and Indigo

Bush (Amorpha fruticosa) invades and can develop into a stable community, only slowly invaded by tree reproduction of the wet forest. (Curtis, 1959)

Aquatic Vegetation

Introduction

The UMRCC published an "Upper Mississippi River Habitat Classification Survey" (Sternberg, 1971). This set up six standard habitat classifications, and indicated the habitat distribution on the Corps of Engineers navigation charts. Helms (1968) differentiated the habitats on an acreage basis for all the pools in the Iowa section of the river. Table 1 gives the data for Pool 10.

Table 1. Acreage and Percentage of Habitats in Pool 10 (% in parenthesis)

Tail-waters	Main Channel	Main Channel Border	Side Channel	Slough	Lake	Pond	Total
28.2 (C.2)	3482.0 (21.8)	2971.9 (18.6)	1579.2 (9.9)	5547.6 (34.8)	2308.5 (14.4)	64.6 (0.4)	16,002.0

The rooted aquatic vegetation is limited to areas which are covered with water the majority of the year. Sufficient depth or turbidity of the water to limit light penetration serves as a limiting factor at the other end of the depth gradient. Shading by other plants and anerobic conditions in the rooting zone also tend to limit certain species to particular zones delimited by water depth (Laing, 1940). The major zones intergrade from the terrestrial marsh, to the emergent aquatic zone, to the floating zone, to the submerged zone, and finally in deeper water to the benthic habitat

with no rooted plants. Because of the restrictions of water depth and current, rooted vegetation is limited to the sloughs and the borders of the lakes, the so-called littoral zone.

While there has been a number of studies on the zonation in lakes and flowages little or no work has been published on the Mississippi. The BSF&W has carried out some surveys of marsh vegetation in Pool 10, (Green, 1947) and evaluated some of the ecological changes since 1930 (Green, 1960)

Prior to the 9 foot channel project there were no major areas of marsh in Pool 10. The topography of the area limited marsh vegetation to the borders of the wooded ridges of levees forming the majority of the bottoms. While there were abundant lakes and ponds on these islands (Martin, 1932) the vegetation of the lakes was limited to river bulrush (*Scirpus fluviatilis*), and a few other species. The lakes and ponds dried up during most summers, placing great stress on most aquatic species, and stranding large populations of fish. Up until 1939 fish rescue operations were carried out in pool 10 (Laughling, 1973) to salvage the fish stranded in the dried up sloughs. These dry periods also permitted the extension of willow regeneration into the shallows. This woody cover tended to increase sedimentation during the next flood and convert the shallows into terrestrial habitat. This pattern was accentuated in the region south of the Wisconsin River where the valley decreased in width.

WILDLIFE

Mammals

The bottomlands of the river were [illegible] a rich fauna of mammals of the timbered bluffs, the higher prairies and particularly those associated with water. The latter included raccoons, muskrats, beavers, river otters, and minks. The bank dwelling muskrats were more abundant than those which built lodges ([illegible], 1950).

Early trapping reduced the numbers of the most valuable species, particularly beaver and otter. Clearing and [illegible] of the islands and river sides, along with the result of industrial developments, reduced the number of mammals.

Birds

The river bottomlands were [illegible] species of swan, and marsh dwelling birds. These included the tree nesting ducks (wood duck and hooded merganser), marsh nesting ducks (mallard and blue winged teal), Canada geese and whistling swans, the herons, shorebirds and marsh and swamp passerines (e.g. redwinged blackbird, yellow throat and marsh wrens). In addition, it was a brood rearing area for waterfowl hatched in the adjoining timber and uplands.

The river also served as a flyway for the migrations of northern waterfowl, some of which then migrated eastward toward Chesapeake Bay (e.g.) canvasbacks, swans, blue winged teal and widgeon) while others continued southward. In general, the river or dabbling ducks utilized the shallow

backwaters, the diving ducks in open water areas, and the geese the sand bars. The dabblers fed on [illegible] submerged pondweeds and the seeds of emergents, the divers such as canvasbacks and ring-necked ducks on submerged pondweeds and wild celery, and divers such as scaup, on bottom molluscs, and the geese on willow sprouts. While most of the ducks migrated in massive flocks or flights, the geese usually migrated in small flocks, stopping on the sandbars until discovered by hunters.

The unregulated hunting of the 1800's extirpated the nesting geese and swans and seriously depleted the local wood ducks. While the old time duck hunters remember the shooting of the "good old days", their success depended upon several factors (Havera, 1985). Later, there were fewer hunters and they hunted seriously. What most remember are the large kills they made, often in excess of the then [illegible] bag, during major flights. They were more patient, concealed, and adept at calling and decoying, and often used live decoys, "call ducks", and [illegible]. The migrating flocks had no refuges and were continually [illegible], and being tired, responded well to calls and decoys. As a result, the hunters had [illegible] shooting with each wave of migrants.

Aquatic Animals

Fish

While the records of the early explorers tell of large catches of large fish, their liberal use of vernacular names, e.g. "trout", "pike", "carp", does not permit a good assessment of species abundance. In

generally, [illegible] and [illegible] and gravel bottoms, [illegible] [illegible] buffalo, [illegible] followed by drum, gizzard [illegible] and finally carp.

[illegible]

[illegible] carp reproduction.

The construction of wing dams [illegible] of water flow and [illegible] for large numbers of [illegible] walleyes ([illegible] and [illegible], [illegible]).

The construction of the [illegible] dam in 1913 for hydroelectric power stopped most upstream movement of migratory fish. This included paddlefish, American eel, skipjack, [illegible] shad, buffalo, shortnose gar, drum, shovelnose sturgeon, [illegible] species of catfishes, and blue suckers. Subsequently there has been a considerable reduction in the numbers of paddlefish, eel and blue catfish, and possibly the extirpation of skipjack and blue suckers north of [illegible] ([illegible], 19[illegible]). No specimens of either of these two have been taken in [illegible] years (Carlander and Spencer, 19[illegible]).

Mussels

The clam beds of the river were relatively undisturbed, except for use as food by the Indians, until [illegible] began in Muscatine in 1889. The beds near Muscatine were rapidly depleted, and by the year 19[illegible] clamming was the most important [illegible] tons were taken. The "nigger-head" was [illegible], with [illegible] numbers of "yellow sand shells", "[illegible]", "[illegible]", "muckets", "deerhorns", "[illegible]", "[illegible]", "[illegible]", and "pocketbooks". There appeared to be [illegible] species of river clams (Carlander, 19[illegible]).

The depletion of the clam beds became apparent due to the intensive clamming. Clams grow slowly, and a 4.5 inch "niggerhead" shell is 15 to 18 years old. In addition, clammers often threw undersize clams or unusable species on the bank so they would not be bothered with them again ([illegible], 19[illegible]). As a result, the early fishery work became concerned with artificially infecting fish with clam larvae and stocking the clams. [illegible] with button blanks during the

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Recreational Activity

Recreational activity has two effects of interest. One is the psychological value to the users themselves of the availability of the Mississippi River for leisure activities. A second effect is the impact of the recreational activity on employment and income. Recreational activity is more indirect in its effect on employment and income than is industrial activity and relates mainly to leisure time activities of people using the Mississippi River for recreational purposes. Examples include boating, sport fishing, hunting, sightseeing, camping, and picnicking. Recreational activities frequently are units of measurement like number of boaters or fishermen using a lake or river, fishing licenses sold, or visitor days. It is often very difficult to find such measures for a particular pool on the Mississippi River. Where such data are available, such as pleasure boat lockages, they are used. Where they are not available, such as fishermen [illegible] are used. For example, number of [illegible] lock and dam [illegible] the pool [illegible] even though [illegible]. Problems involved with placing dollar values on these recreational activities are discussed in Section 4.

Cultural Considerations

[illegible]

historical battlegrounds or buildings, or existing settlements of ethnic groups such as Amish communities. Because of the difficulty of placing any kind of value on such sites, the present study only seeks to identify such sites.

Overview of Socioeconomic Activities in the Study Area

The industrial, recreational, and cultural aspects of Pool 10 are discussed below in relation to the entire Northern Section of the Upper Mississippi River to provide a background with which to analyze the impact of operating and maintaining the nine-foot channel in Section 3 of this report.

Industrial Activity

The existence of the Mississippi River and its tributaries has had a profound effect on the industrial development of the American Middle West. It has served as a route of easy access for transportation and communication tying together the industrialized East with the agricultural Middle West as well as with the varied economies of the North and South.

Historical Development of the Waterway. The development of the Northern Section of the Upper Mississippi as a waterway for shipment has paralleled the rise of the American economy, keeping pace with the need to move bulk raw materials and heavy, high-volume commodities over the wide geographical areas served by the river network. This has allowed barge transportation to remain competitive with other forms of transportation.

It is noteworthy that competing systems of land transportation such as railroads and highway trucking utilize the relatively gentle river valley terrain in order to simplify both engineering design and fuel energy demands. Thus, the Mississippi River Valley is intensively utilized to meet the transportation needs of the Midwest.

Long before the coming of the first white settlers, the Mississippi River was a transportation corridor for the Indians. It was used to facilitate the primitive barter economy and as a route for other forms of social and cultural communication and contact.

In its primitive condition, the Upper Mississippi was characterized by numerous rapids and rock obstructions. Fluctuations in water flow during various seasons of the year were minor inconveniences to the Indian canoe, but demanded modification before substantial commercial use of the river could take place. Prior to improvements, such traffic was limited to periods of high water when log rafts and small boats could pass between the Falls of St. Anthony and the mouth of the Ohio River.

The necessity of modifying the natural course of the river to make it suitable for commercial navigation gradually became apparent as the size of the river boats and barges grew. Since the first river steamboat arrived at Fort Snelling in 1823 steamboat transportation for freight and passenger use grew to a peak in the decade 1850 to 1860 when over 1000 steamboats were active on the entire length of the river. By 1880 the growth of the railroad system in the U. S. and the lack of a channel of sufficient depth marked a decline in the use of the river for transportation.

However, on the upper reaches of the Mississippi, growth in freight traffic continued. A peak was reached in 1903 with 4.5 million tons moved between St. Paul and the mouth of the Missouri River. A subsequent rapid decline coincided with a drop in river use for moving logs and lumber. In 1916 only 0.5 million tons were shipped on this section of the river.

As the population and industry of the Upper Midwest region grew, there was a corresponding growth in the need for cheap coal for power generation. A technological consequence of this need was the development of the barge and towboat which gradually replaced the steamboat on the river. The barge and towboat required a deeper channel than the earlier steamboats. The need for coal in the Upper Midwest was complemented by the need to ship large quantities of grain south to other centers of population. Thus, economies were realized by having at least partially compensating cargoes going both directions on the upper reaches of the river. In the later 1920's large grain shipments from Minneapolis began.

Four and one-half foot and six-foot channels had been authorized by Congress in recognition of the increasing role of the river in the transportation network of the U. S. and with technological developments leading to increased size of barges and tugs the authorization of a nine-foot channel to Minneapolis was passed by Congress in 1930. By 1940 the channel and the requisite locks and dams were essentially complete.

When figures for tonnages shipped at various times on the Mississippi River are examined, it is difficult to make comparisons that relate to Corps' activities. For example, the following factors complicate the problem of data analysis during the period prior to 1940:

1. Statistical data collected by the Corps of Engineers covered different segments of the Upper Mississippi River during these years. Some of the reasons for this appear to be changes in the administration of river segments during that time, as well as some experimentation with better methods of statistical collection.

2. Shipping in the Upper Mississippi was distorted during the decade of the 1930's due to the construction of locks and dams in the St. Paul District.

3. From 1941 to 1945 all forms of transportation were utilized for the war effort without regard to maximizing economic return. Therefore, data for these years (as with the 1930's) does not necessarily reflect a normal period of transportation on the Upper Mississippi.

Barge Shipments. Table 1_a shows tonnage information available for selected years from 1920 through 1945 for the river segment identified in the third column of the table.

Table 1_a River Shipment from 1920 through 1945

Year	Total Tonnage (short tons) Shipments and Receipts**	River Segment
1920	630,951	Mpls. to Mouth of Missouri River
1925	908,005	Mpls. to Mouth of Missouri River
1926	691,637	Mpls. to Mouth of Missouri River
1927	715,110	Mpls. to Mouth of Missouri River
1928	21,632	Mpls. to Mouth of Wisconsin River
1929	1,390,262	Mpls. to Mouth of Ohio River
1930	1,395,855	Mpls. to Mouth of Ohio River
1935	188,613	St. Paul District
1940	1,097,971	St. Paul District
1945	1,263,993	St. Paul District

** Tonnages exclude ferry freight (cars and other) and certain cargoes-transit.

* Source: Annual Report of the Chief of Engineers, U. S. Army, Part 2 "Commercial Statistics", Table 7, by selected year.

In more recent years, data are available for the St. Paul District. Table 2 shows the movement of tonnages through the St. Paul District for the years from 1962 through 1971.

Table 2. River Shipment from 1962 through 1971. [a]

Year	Total Traffic St. Paul District*
1962	8,168,594
1963	9,266,361
1964	9,621,336
1965	9,265,538
1966	11,346,457
1967	11,618,849
1968	10,736,350
1969	12,[illegible]7,428
1970	15,423,713
1971	15,070,082
1972**	16,361,174

* Comparative Statement of Barge Traffic on Mississippi River and Tributaries in St. Paul District, U.S. Army Engineer District, St. Paul, St. Paul, Minnesota

** Estimated

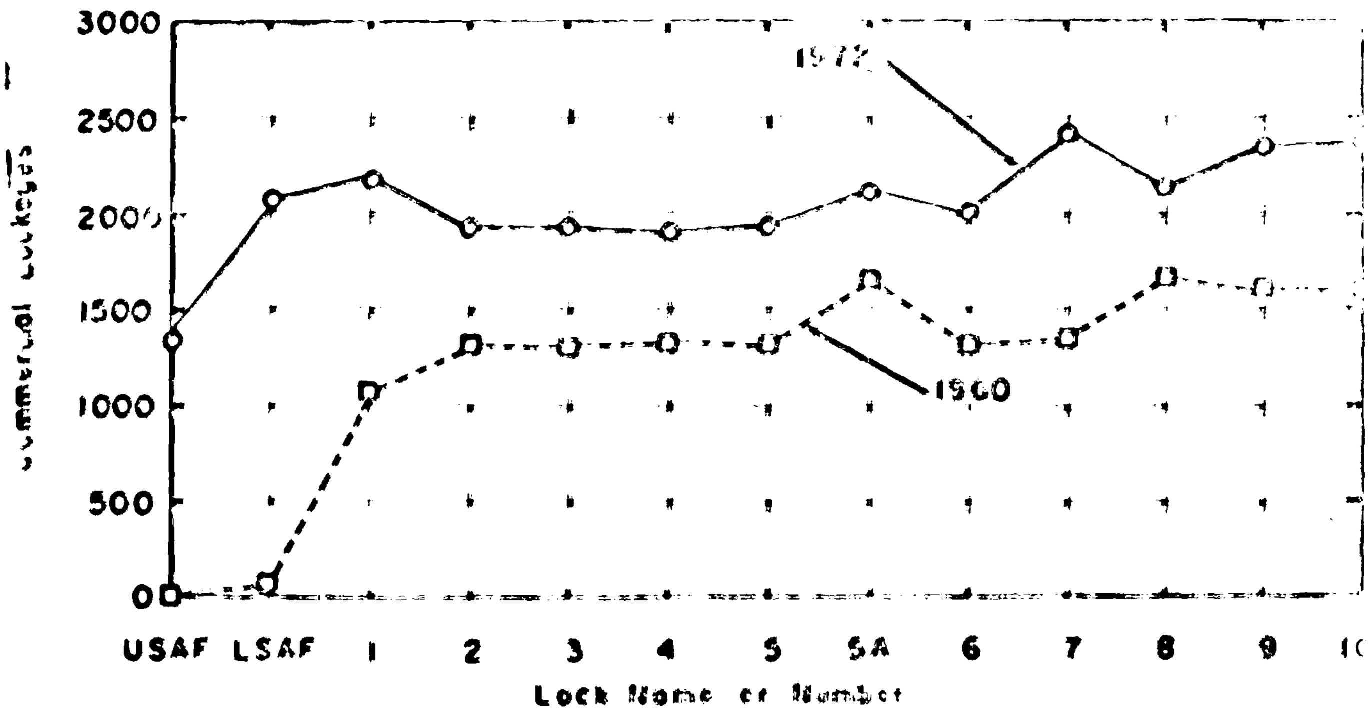
When this table is compared with the previous one, the growth of shipping on the Upper Mississippi becomes readily apparent. Thus, the total traffic for the St. Paul District in 1962 was about six times the traffic in 1945, which was a war year. In fact, traffic in the St. Paul

District for 1962 was more than five times greater than all of the traffic on the Upper Mississippi between Minneapolis and the Mouth of the Ohio River in 1930. Traffic about doubled in the St. Paul District between 1962 and 1971. This was due to a large degree to grain shipments from the District and to an increase in receipts of coal.

In 1929 data were collected on receipts and shipments for the river segment from Minneapolis to the mouth of the Wisconsin River. This approximates the navigable segment of the Upper Mississippi within the St. Paul District, and the data for this segment can be equated with data for the St. Paul District with little difficulty. In that year, [illegible],609 tons were received and shipped. By 1940, tonnages handled reached 1,000,000 tons annually when the lock and dam system and the nine foot channel were virtually complete. Tonnages totaled 2,000,000 by 1946, and 3,000,000 by 1953. By 1962 over 8,[illegible],000 tons were shipped and received in the St. Paul District. In the decade between 1962 and 1972 this had doubled to 16,000,000 tons.

The shipping season for most of the Mississippi River within the St. Paul District is usually eight months, from mid-April to mid-December. The navigable rivers maintained and operated by the St. Paul District should be viewed within the context of the system as a whole including the Mississippi, Ohio, Missouri and other tributary rivers. In 1964 a detailed analysis of origin-destination waterborne commerce traffic patterns showed that the average miles per ton on the Upper Mississippi River Waterway System [illegible]

great bulk of shipments and receipts [illegible] outside the St. Paul District. Each pool [illegible] and receipts contributes to [illegible] the system as a whole. Thus, any measure of the economic benefits of the river commerce on an individual pool must include the benefits that it contributes as a necessary link in the Upper Mississippi system. An indication of the "thoroughfare" function that each pool provides [illegible] traffic in the study are the commercial lockages [illegible] locks in the Northern Section that are shown in Figure 11. These also provide another indication of the recent increase in barge traffic. From 19[illegible] to 19[illegible] the number of lockages in the portion of the river between Lock and Dam 1 and Lock and Dam 10 increased by about [illegible].



Source: St. Paul District, [illegible] U. S. Army Corps of Engineers, Annual Lockage Data, [illegible]

Figure [illegible] [illegible] Upper Mississippi River [illegible]

[illegible]

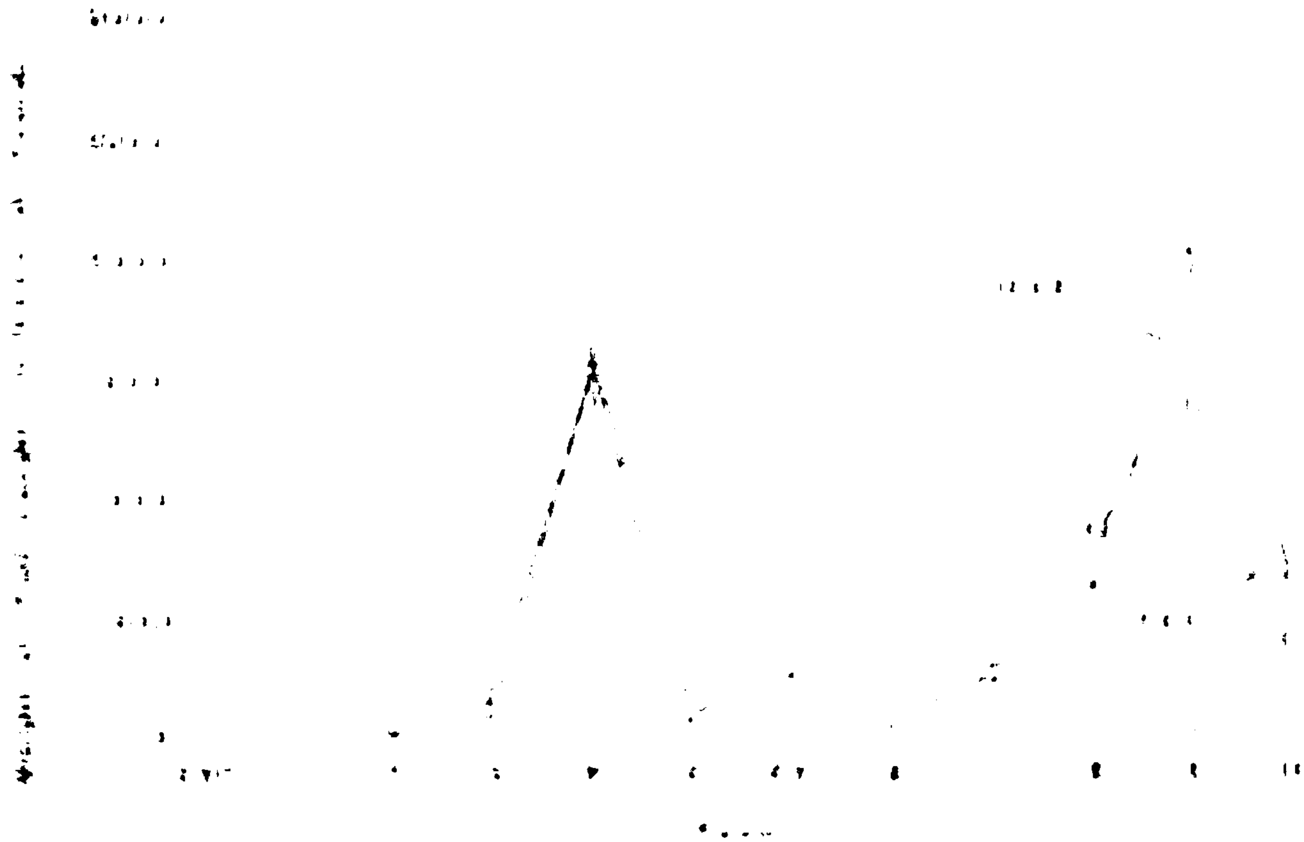
Limited [illegible] fishery [illegible] power [illegible] created the [illegible] over that [illegible]

Data on [illegible] study area are shown in [illegible] Upper Mississippi [illegible] that were sold commercially [illegible] total. The commercial value [illegible] about [illegible]

Trapping [illegible] in the Upper Mississippi [illegible] is managed by Bureau of Sport [illegible] and Wildlife [illegible] of the Interior. This refuge was established by Congress [illegible] and runs for 284 miles along the Upper Mississippi River from [illegible] Minnesota to above Rock Island, Illinois [illegible] from [illegible] Lock and Dam [illegible] to Lock and Dam [illegible] of [illegible] trappers per year [illegible] trapping [illegible]

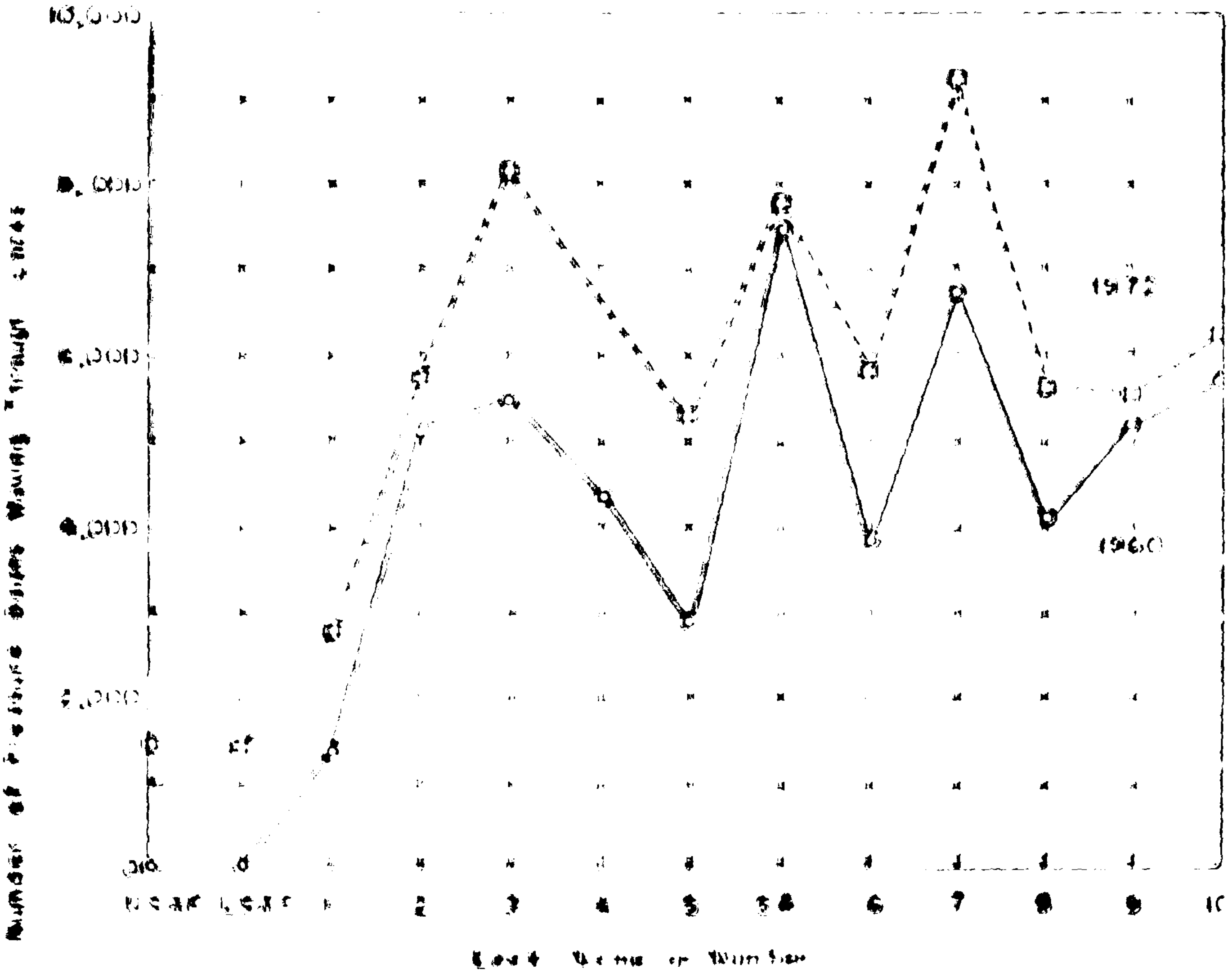
[illegible] averaged nearly [illegible] 19[illegible] [illegible], the price of [illegible] was valued at about [illegible]

Figure [illegible] commercial fishing in the pools in the [illegible] and [illegible] percent of the total [illegible] the major [illegible] 10 contributed [illegible] the relative [illegible] from [illegible] commercial [illegible]



[illegible]

[illegible]


10,000
8,000
6,000
4,000
2,000
1972
1960
2
3
4
5
6
7
8
9
10

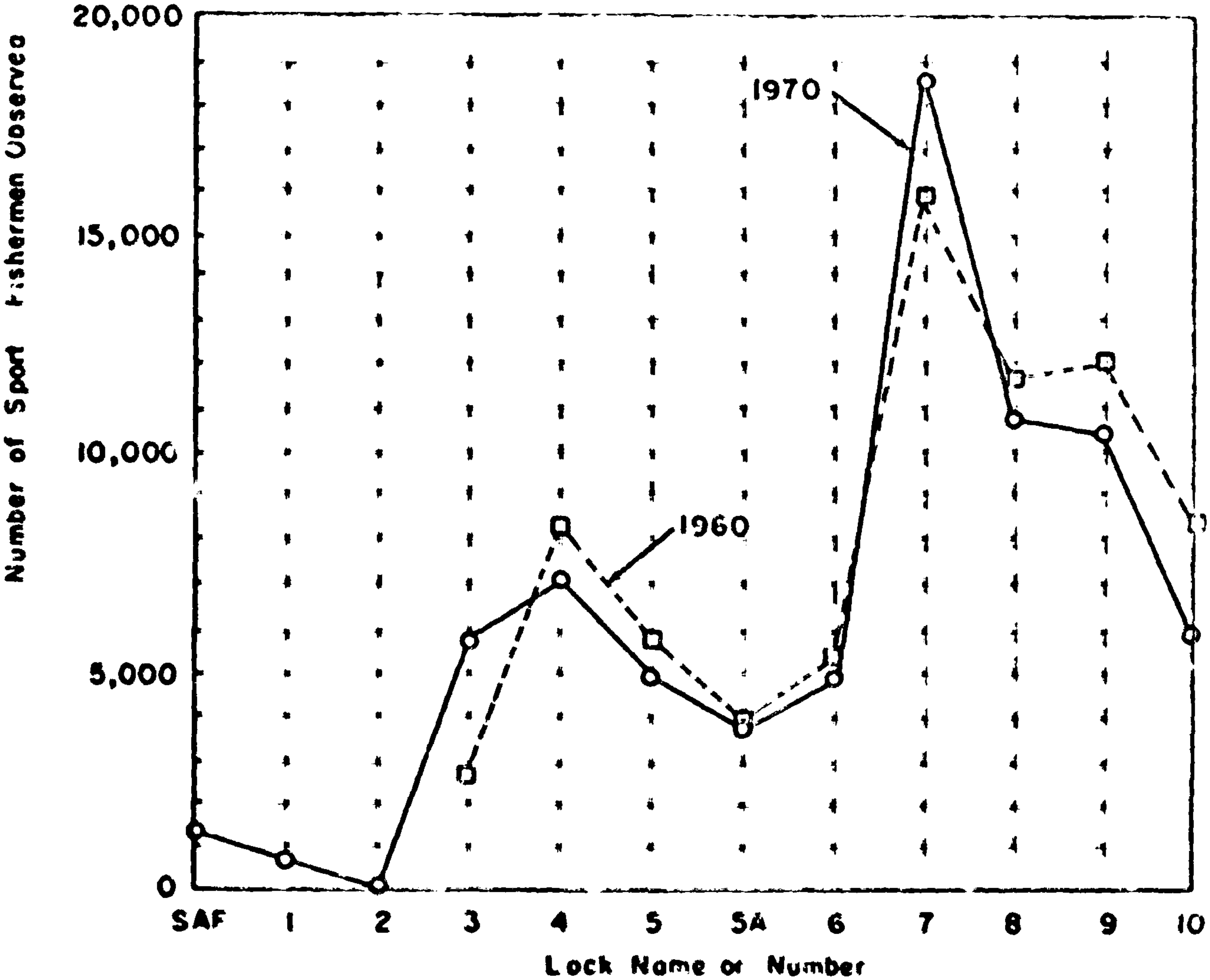
In 1968 [illegible] facilities that were [illegible] (31, [illegible] and lands [illegible], as well as [illegible] the state parks. [illegible] is accommodated by 20 [illegible] developed in the pool area by various Federal and non-Federal [illegible] and private interests. Most of the [illegible] water type activities and, [illegible] facilities for other activities [illegible] that of the 20 public [illegible] Bureau of [illegible] Forest Service lands, [illegible] municipal lands.

[illegible] of the 20 sites, [illegible] the principal use of most of [illegible] parking facilities generally [illegible] it can be assumed [illegible] for parking of cars and boat trailers. [illegible] parking spaces available, [illegible] supplemental parking when [illegible] conditions permit.

Sport [illegible] estimates of the number of sport fishermen [illegible] not available. Although sport fishing [illegible] 6, 5, and 7 [illegible] the study area

comparable data do not [illegible] for the [illegible] of the pools. Probably the best data available are the number of sport [illegible] observed annually by attendants at lock and dam sites. Attendants at each lock and dam observe the river pool areas above [illegible] at 2:00 p.m. each day and record the number of sport [illegible]; the annual data are simply a sum of these daily estimates. Sport hunting of waterfowl along the Mississippi study area is large. It is estimated that in 1963, the year for which the most [illegible] data are available, about 9,000 visits by hunters were made to Pool 10. This [illegible] is somewhat greater than the average observed for Pool 10 [illegible] period from 1961 to 1970. For this period the Upper [illegible] Wildlife and Fish Refuge estimates that an average of [illegible] hunters visited Pool 10 annually and [illegible]

The number of sport fishermen [illegible] at each lock and dam in the study area are shown in Figure 14 for the years 1960 and 1970. There has been little change during the [illegible] period of the number of sport fishermen [illegible]. [illegible] tend to seek water with a high concentration of dissolved oxygen and the dams tend to aerate the water, the bulk of the sport fishermen tabulated in Figure 14 are probably [illegible] the pool downstream from the lock and dam cited on the horizontal axis of the figure. Pool 10, below Lock and Dam 9, had more than 10,000 sport fishermen observed by attendants.



Source: UMRCC, Proceedings of Annual Meeting, 1962 and 1971.

Figure 15. Number of Sport Fishermen Observed Annually by Attendants from Lock and Dam Sites on the Upper Mississippi River in 1960 and 1970.

Sightseeing and Picnicking. Studies in general indicate that a body of water is often essential for most recreation activities. People want this water not only to boat on or to fish or swim in, but also simply to look at, picnic beside, and walk along. The study area of the Upper Mississippi has served this purpose for settlers for two centuries. Again, because precise data are lacking, it is generally difficult to isolate the effect of Corps' operation on recreational activities such sightseeing, picnicking, and hiking. To assist sightseers, the Corps of Engineers operates eight overlooks at locks and dams in the study area. In addition, a variety of parks exist along the river that are available for sightseeing and other recreational activities.

Cultural Considerations

A number of archaeological, historical, and contemporary sites exist in the study area. A complete survey of archaeological sites had not been made prior to 1930 but no identified sites in Pool 10 are known to have been affected by operations of the Corps of Engineers.

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5. [illegible]

INTRODUCTION

The [illegible] of a [illegible] foot [illegible] resulted [illegible] the con-struction [illegible], a [illegible] population coordinated with the dams both [illegible] Lock and Dam 10, and a long term program of maintenance dredging [illegible] the channel [illegible] from sedi-mentation. In addition [illegible], the improvement of navigation, and the [illegible] population [illegible] resulted in an expansion of urban and industrial [illegible]. While direct [illegible] Lock and Dam 10, there has been an increase [illegible] from [illegible] of the surrounding urban centers.

NATURAL SYSTEMS

While all [illegible] natural systems, we are primarily [illegible] from the Corps of En-gineers [illegible] a navigation channel. The three primary activities in the nine foot channel project were the building of the wing dams, the construction and operation of the lock and dam, and the conti-nous maintenance dredging to deepen the channel.

Wing Dams

The first major impact on the river developed with the construction of wing dams and closing dams for the six foot channel project. The surround-ing bluffs were modified by quarrying activity for the stone for the wing dams. [illegible] of willows

for [illegible] as making [illegible]

mi [illegible]

The [illegible] been [illegible]

They have been [illegible]

[illegible]

The wing dam [illegible] action of the current, [illegible] the [illegible] from the [illegible] a series of [illegible] and other game fish [illegible] half of the pools.

[illegible]

The [illegible] the silt [illegible] of the islands, [illegible] These are the same effects that improve navigation [illegible] in the backwaters. Since the effects of the wing dams are [illegible] to dredging the total effects of both will be discussed in the section of dealing with dredging impacts.

[illegible]

The construction of the lock and dam [illegible] in direct destruction of the vegetation [illegible]

[illegible]

The [illegible] approximately [illegible] dam condition [illegible] present condition [illegible] the dam [illegible] flow during the [illegible] extreme [illegible]

Beneficial [illegible]

In [illegible]

pool [illegible] organisms [illegible] in the [illegible] in transect [illegible] below.

Average [illegible] in Pool 10.

(Values in [illegible])

Transect [illegible]	[illegible]	[illegible]	[illegible]
June [illegible]	[illegible]	[illegible]	[illegible]
[illegible] 1,0[illegible]	[illegible]	[illegible]	17[illegible]

[illegible] diving ducks [illegible] food, [illegible] and [illegible] Pool 16 [illegible] more than [illegible] of Pool 16. During [illegible] varied from 666, [illegible].

The [illegible] of the [illegible] Pool 16 [illegible] pools [illegible] 1953)

[illegible] aquatic vegetation [illegible] swarms [illegible] developed high [illegible] 1950's the [illegible] in aquatic plant populations [illegible] to pre-flood levels in the upper end of [illegible] (Green, 1960). At present there were no stands of submerged aquatic [illegible] fringe of emergents along the upper end of the pool [illegible] result of the stabilization of water levels in the upper [illegible] of the pool.

The [illegible] in the [illegible] of the pool, [illegible] Bottoms and [illegible] high populations of [illegible] (Vallisneria [illegible]).

[illegible]

[illegible]

[illegible]

[illegible] 1965). Yet the [illegible] river [illegible] their [illegible] because the [illegible] the railroad tracks which border the river, and those in the tributaries [illegible] a long journey through the stream, which [illegible] result of

[illegible]

[illegible]

[illegible]

[illegible] the 1930's and 1950's [illegible] vegetation, particularly [illegible] has declined. This deterioration is [illegible] a number of factors; 1) the vegetation has been buried [illegible], especially during the increasing number of floods, and the dam probably has augmented this precipitation of sedimentation; 2) the water has been increasingly turbid during the growing season; 3) the herbicide runoff could be weakening or killing the vegetation; 4) the high population of carp, which were

[illegible] to the [illegible] wade [illegible] from [illegible] have several [illegible] were opened [illegible] closed [illegible]. Thus, [illegible] still higher than prior to the dams, [illegible].

[illegible] to the pools above [illegible] of the [illegible] very low due to the [illegible] of the river [illegible] themselves. [illegible] specific [illegible] of the population [illegible] Wisconsin, [illegible] (6,000 to 8,000) [illegible].

No assessment of the turtles, water snakes, mud puppies, salamanders, frogs, and toads has been made. There has been an increase of shallow water habitat for these species from inundation, but loss of the island area has reduced habitat for [illegible] toads and salamanders, and loss of sandbars has reduced the nesting habitat for turtles. Turtle eggs laid on small islands are not as susceptable to mammalian predation as those on large islands or on shore, where few eggs go undiscovered. Mud puppies

are exceedingly abundant in the [illegible] sloughs.

The construction of the lock and dam [illegible] created a [illegible] pool, causing a change from fast water species to [illegible], and an increase in fishes whose environment is pool-like, such as the large mouth bass, bluegills, crappies, carp, buffalo, and walleye (Carlander and Sparks, 1951). The dams also slowed the current, effecting an increase in the sedimentation of silt which is more important than the increase of stabilization of water area [illegible], 19[illegible]). The sediment covers sand and gravel bars necessary for the feeding and breeding of certain fish, as small mouth bass and walleyes. Studies on the [illegible] indicate that they also require gravel [illegible] particular water depths for feeding, so that sedimentation may have been responsible for the reduction of populations (Helms, 1973). There has been a corresponding increase of fish which are tolerant of mud bottoms.

The increase in relative numbers of carp, gar, and bowfin has been felt by many fishermen to depress the number of gamefish. The increased turbidity, probably intensified by the carp feeding, would interfere with the feeding by gamefish, which feed by sight. The increase of gar and bowfin are felt to cause serious predation upon gamefish ([illegible], 1973).

The increased sedimentation has filled in the backwater sloughs to the point where they suffer winter kill via oxygen depletion or freeze-out. The effects of sedimentation upon foods of fishes is largely unknown, but by killing of submerged vegetation such habitat for small fish and crustaceans is destroyed. The mud bottom is beneficial to fingernail clams, an important

food of carp and catfish in Pool 19 [illegible]. However, the silt may be quite detrimental to the important bottom dwelling insects (C[illegible] flies, caddis flies, and [illegible]). In Pool [illegible], the upper end of the pool which has been most affected by sedimentation has the lowest populations of invertebrates, including the fingernail clam, and submerged aquatic plants.

The inhibition of the migration of the [illegible], the main host for the larva of "niggerhead" clams, all but eliminated this clam. In the 200 tons of clams taken from [illegible] 19[illegible], about "a dozen were niggerheads" (Lessard, 19[illegible]). The [illegible] are "washboards" and "three ridges" with lesser amounts of "[illegible]", "warty-backs", and "maple leafs".

The clammers felt that sedimentation has destroyed much of the clam beds although high turbidity also [illegible]. Since clammers use an underwater sail or "mule" for propulsion over the beds, they are aware of the changes of the rate of flow over the beds. They are quick to point out that not only has the average rate of flow decreased; but by closing the dam rollers the flow essentially ceases on certain days (Lessard, 1974).

Dam Operation. In the basic plan of operation of Dam 10 when discharge exceeds 42,00 cfs. control is shifted to Clayton and the pool is allowed to rise to 611.8 ft. at Clayton. At this point when discharge exceeds 52,000 cfs. control is shifted back to Dam 10 and the lower pool will be

[illegible] of a pool [illegible] habitat. [illegible] and marsh areas [illegible] conditions in [illegible] in the lower [illegible], especially in [illegible] ing. [illegible] to a foot has been implemented since 19[illegible] relieved; However the problem is fur[illegible] the increased pool elevation at [illegible] coupled with th[illegible] pool at the d[illegible] results in a drop of 2 feet in 9 miles. The resulting [illegible] place a stress on all communities in the marsh areas in the lower third of the pool.

Dredging

Since all the tributaries continue to bring sediments, as a result of erosion of the uplands, into the river, there is contineous deposition of

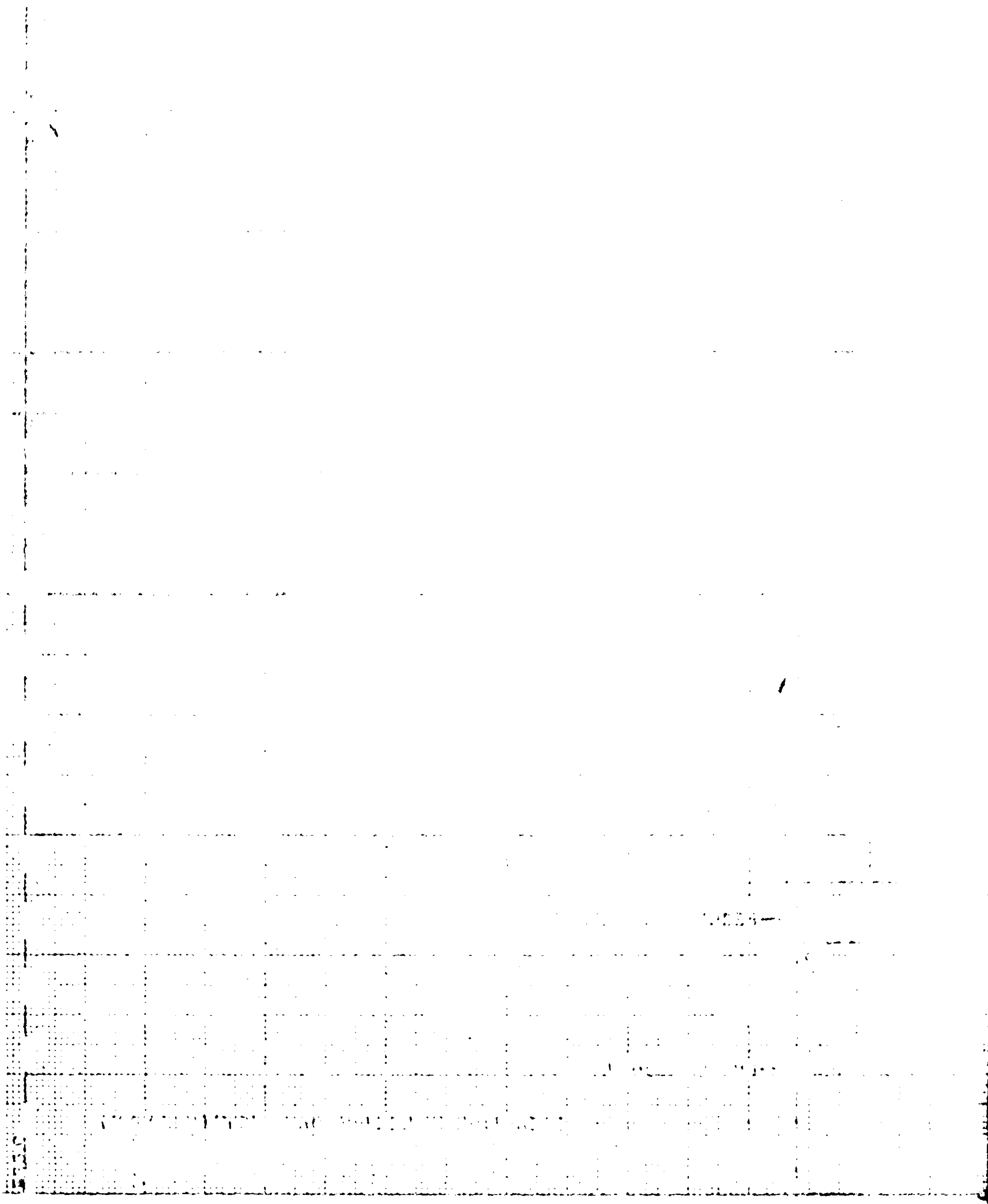

Figure 15. Operating Curves, Lock and Dam No. 10

material into the [illegible] configuration and [illegible] lands. [illegible] necessary to maintain channel depths.

Beneficial Effects

The maintenance of [illegible] and the [illegible] of recreational beach sites along [illegible] result [illegible] dredging activity.

Detrimental Effects

Dredging [illegible]. Dredging produces [illegible] and any toxic substances [illegible] of this effect needs to be [illegible] of the problem.

The long term [illegible] project [illegible] resulting from dredging. [illegible] bottom lands, adjacent to the channel and [illegible] dams. The habitat is affected in several ways:

1) By filling in slough [illegible] and removing aquatic habitat. This has a major effect on both [illegible] and furbearers since these slough areas are primary [illegible] and feeding sites. The changes in the littoral zone of shallow waters may also effect food production for water fowl by changing the zone of emergent and submerged vegetation and modify spawning beds for fish. Recreational use of Pool 10 is also affected both by the danger from submerged wing dams and from silted in

[illegible] the [illegible] Sny Magill [illegible].

2) By [illegible] plains [illegible] mature [illegible] in [illegible]

3) If not stabilized it [illegible] turbidity [illegible] again [illegible].

4) By blocking [illegible] will result [illegible] and [illegible], [illegible]. The lack of [illegible] will [illegible] in the [illegible]. [illegible] aeration [illegible] combination of lack of [illegible] depletion of oxygen under the ice cover, resulting in winter kill of fish. It can also hinder boating access to the backwaters.

This latter factor is the major problem with dredging in Pool 10. Wyalusing slough, on the Iowa side (mile 6[illegible]), supplies flow to this entire backwater area, 3,600 acres, and regulates water levels to permit boating access from the Sny Magill Addition, Effigy Mound National Monument, to the river. At this point in the main channel, just below the mouth of the Wisconsin, a combination of natural sedimentation [illegible]

wing [illegible] Wyal[illegible] [illegible] and the [illegible] Clayton [illegible] In [illegible] channel [illegible] into [illegible] with a [illegible] out in the 1965 [illegible]

In twenty [illegible] years, [illegible], a total of [illegible] of terrestrial [illegible] and accumulation [illegible] along 10 miles of river [illegible] to 25% of this [illegible] river.

Pool 10 [illegible] limited to [illegible] until 19[illegible] equival[illegible] to 1[illegible] tons of [illegible] of the yearly sediment load of Wisconsin river. This [illegible], or if we just consider the reaches of the river [illegible] 9,750 cu yds/mi/yr.

[illegible]

[illegible] ... [illegible] and [illegible] caused in [illegible].

[illegible]

[illegible] the study area of [illegible], recreational, and [illegible].

[illegible]

[illegible] considerable [illegible] relatively [illegible] of the [illegible] in [illegible] Pool 10 [illegible]:

1. [illegible] located in [illegible].

2. [illegible] portions of the Upper [illegible].

3. [illegible] to the operation of Lock and Dam 10.

4. An [illegible] of [illegible].

5. More [illegible] reduced [illegible].

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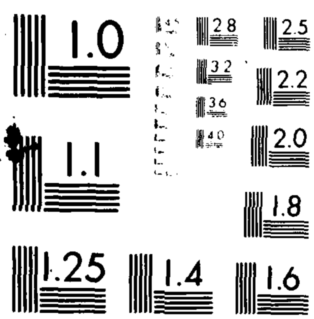


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

To summarize, beneficial industrial impacts that result from operating and maintaining the nine-foot channel and its associated locks and dams by the Corps of Engineers are, the through-traffic link for commodities moving up and down the river, the employment in lock and dam and commercial dock operations, and an initial increase in the potential for commercial fishing. The detrimental effects are a decline in water quality due to river barge movement and spills and with continued improper dredge spoil placement -- a likely decline in commercial fishing.

Recreational Impacts

1. An increase in recreational boating due to stable, navigable water levels which leads directly to more recreation facilities -- and their accompanying employment.

2. An immediate increase in sport hunting and fishing due to an increase in --

   a. Waterfowl habitat, and

   b. Fish spawning areas resulting from rising water level.

   Again, as with commercial fishing cited above, improper dredge spoil placement has recently had a detrimental effect on sport hunting and fishing.

3. An increase in sightseeing visitors to the locks and dams at both ends of the pool.

Cultural Impacts

There has been limited impact from the direct action of the project and a greater impact from indirect effects of cultural developments along the river.

Discussion of Impacts

The industrial, recreational, and cultural impacts identified above are examined in detail in the following three sections. Resource implications of these three socioeconomic impacts are discussed in Section 6.

Industrial Activities

The economic effect of the activities of the Corps of Engineers on the Mississippi River in the St. Paul District can be measured mainly in terms of three major elements. They are:

1. The channel itself with its associated locks and dams and navigational aids;
2. The installations at riverside for the transfer of cargo, storage facilities, and access;
3. The vessels using the waterway.

In these terms the impact of the Corps' activities in Pool 10 is not as great as in some of the other pools in the Northern Section of the Upper Mississippi River.

Barge Activity. The greatest and most obvious impact of the activities of the Corps of Engineers in Pool 10 has been the modification of the transportation system due to the growth of barge traffic. The visual evidence of the impact is seen in the physical structures (e.g. locks and dams, and the five commercial docks and terminals) on the shores and the barge tows moving along the river. However, Pool 10 has

not been the origin or terminal for most of the commodities that move in barges along the Upper Mississippi River. Rather, it serves as an important water link between important commodity terminals upstream and downstream from it.

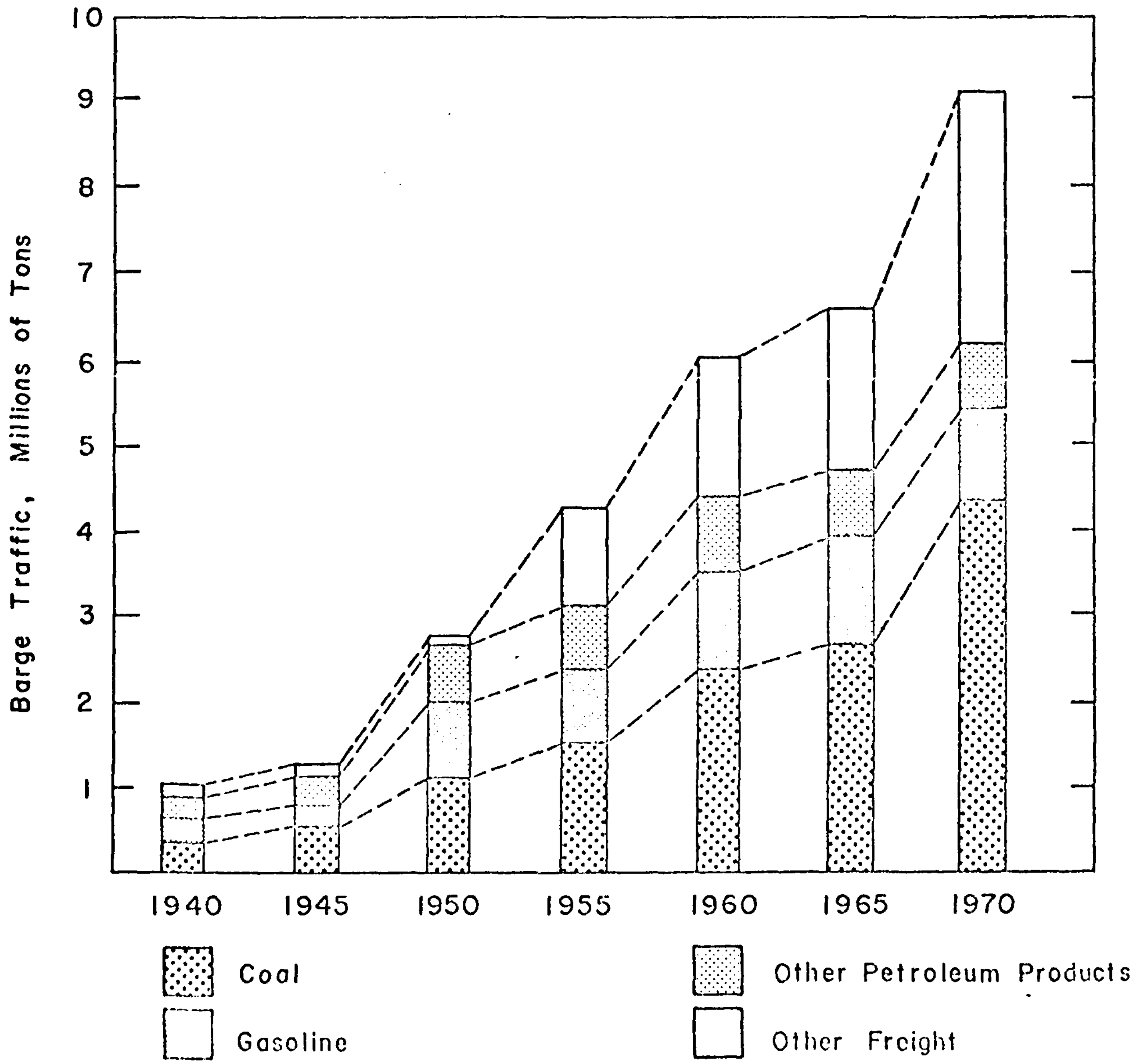
Figures 16 and 17 show graphically the growth of receipts into and shipments from the St. Paul District in the 30 years from 1940 to 1970. Commodities shown in the figures illustrate the diverse economic activity within the St. Paul District; this diversity also applies to the five commercial docks in Pool 10 that handle coal, sand, gravel, salt, fertilizer, and grain. However, the vast bulk of these commodities flow through the pool enroute elsewhere. Although receipts in the St. Paul District still substantially exceed shipments, the growth in shipments (89 percent grain) from the district in these three decades indicates the great impact of the river on the regional economy.

In 1970 some rough projections (based on 1964 data) were made of the growth of commerce in the St. Paul District (UMRBS, Study Appendix J, 1970). The projections suggest that the tonnage of barge traffic moved in the Upper Mississippi River basin will about double from 1964 to 1980 and about triple from 1964 to 2000.

It is noteworthy that receipts into the St.Paul District have always exceeded shipments. In earlier years this imbalance was often extreme (e.g., 1953 receipts = 3,052,144 tons, shipments = 334,233 tons). Recently however the ratio has been around 2:1. Inasmuch as grains and

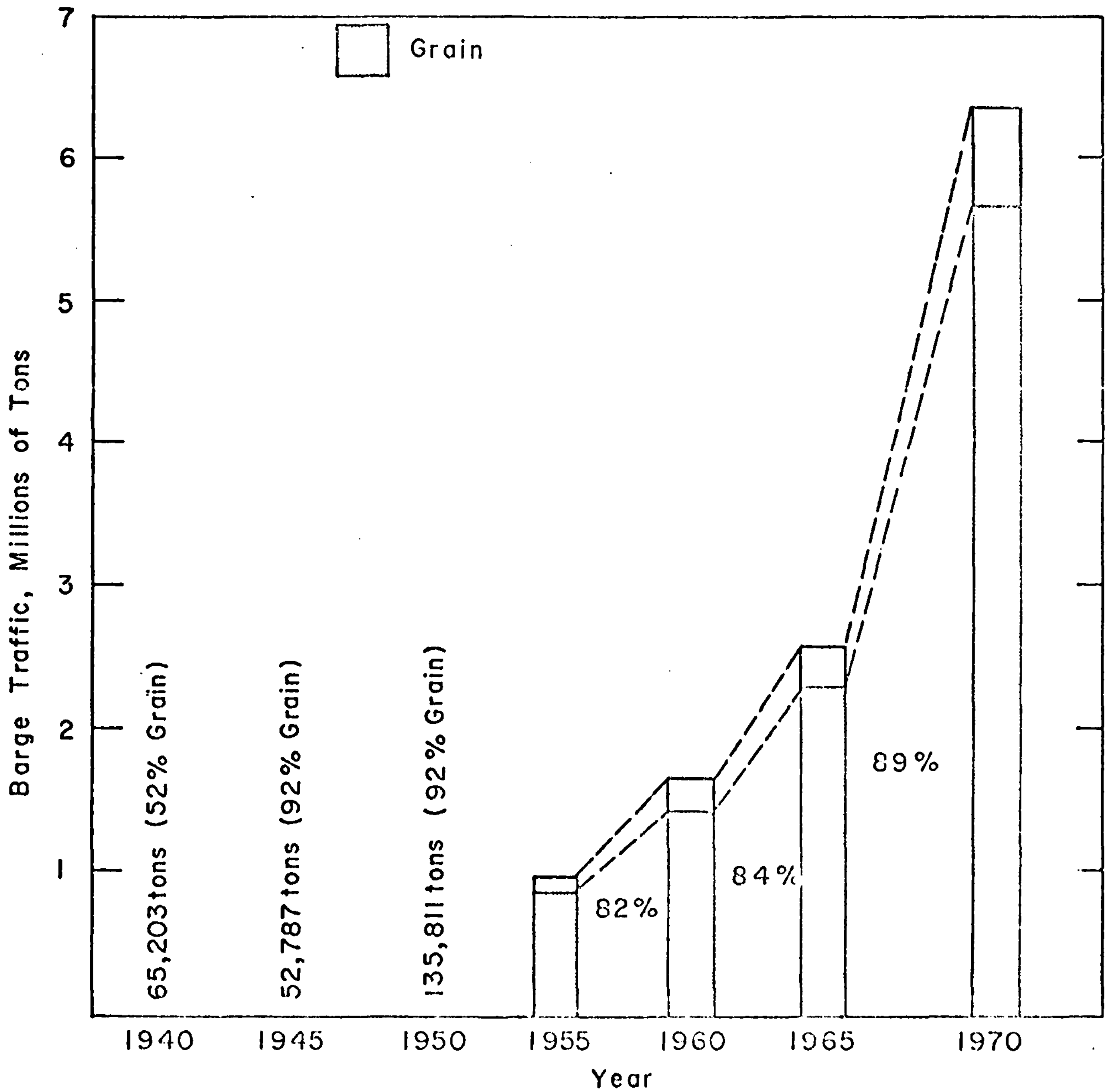
Source: Based on Data from U. S. Army Corps of Engineers, St. Paul District, St. Paul, Minnesota

Figure 16. Receipts of Major Commodities -- All Ports, St. Paul District



Source: Based on data from U. S. Army Corps of Engineers, St. Paul District, St. Paul, Minnesota.

Figure 17. Shipments Out of the St. Paul District



soybeans constitute the preponderant tonnage of shipments, fluctuation in waterborne transport of these products can be profound due to crop conditions and storage facilities, foreign sales, and competing forms of transportation.

Data are not available on the numbers of vessels originating, terminating, or passing through the St. Paul District. However, some comparative idea of shipping activity can be gained from the following information. Vessel traffic measured in tons from Minneapolis to the mouth of the Missouri River is shown for selected years as follows:

Year	Total Vessel Traffic (Tons)
1962	30,526,626
1964	34,108,482
1966	41,311,941
1968	46,174,929
1970	54,022,749
1971	52,773,097

Statistics on the numbers of vessels originating, terminating, or passing through Pool 10 are not available directly. However, some comparative idea of barge activity can be gained from studying the commercial lockages through Lock 10 and Lock 9 -- the locks at either end of Pool 10 -- which are shown in Table 3. From 1960 to 1972 commercial lockage through Lock 10 increased by 46 percent and those through Lock 9 increased by 45 percent.

Table 3. Commercial Lockage in Pool 10, 1960-1972

	Commercial Lockages	
Year	Lock 10	Lock 9
1960	1,621	1,606
1961	1,392	1,538
1962	1,487	1,646
1963	2,082	1,627
1964	1,968	1,754
1965	1,641	1,351
1966	2,345	1,724
1967	2,156	1,776
1968	1,813	1,748
1969	1,885	1,823
1970	2,349	2,101
1971	2,327	2,324
1972	2,373	2,336

Source: Annual Lockage Data, (St. Paul, U. S. Corps of Engineers, St. Paul District, Unpublished Reports).

Commercial Dock Facilities. Five commercial docks serve the needs of Pool 10. Three are located on the Wisconsin side of the river and serve Prairie du Chien; these docks (including one owned by Farmco Company) handle coal, salt, fertilizer, steel, and grain. In addition two very active commercial docks serve grain shipper in Iowa -- one at McGregor (operated by the Farmers Grain Dealers Association) and one at Clayton.

Commercial Fishing. Pool 10 supports a substantial level of commercial fishing, although it produces only about 30 percent of the catch provided by Pool 9. There is no discernable trend in the catch data for this pool. Generally high catches in 1960 and 61 dropped in 1962 to the lowest point for the period shown in Table 4 , but in 1968 and 1969 these early peaks were exceeded when annual catches of about 650,000 pounds were recorded. However, this was below the peak catch observed in the past two decades, which was the 827,000 pounds recorded for 1959.

Increased commercial fishing in Pool 10 since the lock and dam construction is at least partially due to the initial beneficial impact of a larger area of fish habitat caused by the rising water level. However, in recent years improper dredge spoil placement and sedimentation behind wing dams has reduced fish habitat; many fishermen believe this has reduced the supply of fish. Spoil dumping in backwater areas has restricted fishing access to slough and side channel areas in the Clayton-Wyalusing region, thereby reducing the acreage of available fish habitat.

Table 4. Pounds of Fish Caught Annually by Commercial Fishermen in Pool 10 of the Upper Mississippi River, 1960 to 1969.

Year	Commercial Fish Catch
1960	405,000
1961	625,000
1962	296,000
1963	396,000
1964	518,000
1965	Not Available
1966	564,000
1967	580,000
1968	644,000
1969	663,000

Source: Proceedings of the Annual Meetings of the Upper Mississippi River Conservation Commission, 1962-1971.

Major year-to-year variations in commercial fish catches are probably less affected by the supply of fish in the river than by market demand, as reflected in prices commercial fishermen receive for their catch. For example, high meat prices in mid-1973 have caused fish prices to increase with an attendant increase in commercial fishing activity on the river (Fernholtz, personal communication).

Recreational Impacts

Recreational impacts may be divided into boating activities and related facilities, sport fishing and hunting, and sightseeing and picnicking.

Boating Activities and Related Facilities. For Pool 10 a principal measure of pleasure boating activity is the record of pleasure boats locking through Locks 9 and 10 -- the locks at each end of the pool. These data -- along with the total pleasure-boat lockages through these two locks -- are shown in Table 5 for the years 1960 to 1972. The table shows small increases in pleasure craft locking through both Lock 10 (from about 5,700 in 1960 to about 6,200 in 1972) and Lock 9 (from about 5,200 in 1960 to 3,300 in 1972) during the period. The table also shows an accompanying increase in the number of pleasure boat lockages during the period, for Lock 10 but not for Lock 9.

These lockage data probably understate the boating activity in Pool 10 for several reasons. One is that intra-pool movement of small boats for recreation and fishing purposes are omitted, and there is unusually high movement of such boats by water and by boat trailer within Pool 10.

Table 5. Measures of Boating Activity in Pool 10, 1960-1972

	Pleasure Boats Through		Pleasure Boat Lockages Through	
Year	Lock 10	Lock 9	Lock 10	Lock 9
1960	5,654	5,186	2,729	2,677
1961	5,870	5,596	3,100	2,947
1962	5,097	4,333	2,763	2,371
1963	6,218	5,243	3,209	2,785
1964	6,720	5,468	3,460	2,979
1965	4,326	3,935	2,485	1,984
1966	5,919	4,816	2,614	2,634
1967	4,957	4,445	2,548	2,380
1968	5,575	4,370	3,105	2,466
1969	5,405	4,131	2,841	2,081
1970	6,166	4,430	3,086	2,259
1971	6,076	4,983	2,986	2,415
1972	6,196	5,465	3,206	2,638

Source: Annual Lockage Data, (St. Paul, U. S. Corps of Engineers, St. Paul District, Unpublished Reports).

In addition a significant amount of boating - fishing pressure in the Bagley area from two large commercial camping areas is restricted to Pool 10 because of being blocked from the main channel most of the summer due to snags and the low water level in sloughs.

The nine-foot channel and associated locks have provided controlled water levels that have contributed significantly to the increased boating activity in Pool 10. Increased regional population, higher levels of family income, and more leisure time have also contributed to increased activity. The increased pleasure boating has led directly to 20 public-use sites described in Section 2. The presence of Corps' operations on the river has also led directly to several beneficial impacts for boaters in Pool 10. For example the Corps of Engineers constructed a small-boat harbor or city-owned land at Prairie du Chien and, along with U. S. Bureau of Sport Fisheries and Wildlife has constructed a public-use site at Jay's Lake Landing.

Thus a variety of physical facilities have been developed in Pool 10 that exist mainly to serve boaters and fishermen using the pool. These include:

Facility	Number
Small boat harbors, marinas, boat clubs	3
Recreational sites	3
Public boat launching sites with parking areas	18
Commercial recreational sites	15
Wildlife refuges	1

Except possibly for the recreational sites without ramps, which do not cater primarily to boaters, all of these facilities result from Corps' operations on the river that contributed the channel and controlled water levels. The wildlife refuge is aided by the higher water level following the river impoundment that led to several hundred acres of very productive waterfowl habitat.

Sport Fishing, Hunting, and Other Recreational Activities. The size of the pool, and the variety of access points, and the lack of an adequate survey program have precluded obtaining an accurate count of Pool 10 visitation for past years. Neither the Wisconsin Department of Natural Resources (Fernholtz, personal communication) or the Iowa Conservation Commission (Brenton, personal communication) nor the U. S. Bureau of Sport Fisheries and Wildlife (Chase, personal communication) have recent, continuing data on sport fishing, sport hunting, and other recreational activity for Pool 10. The most precise data available are for 1963 and appear in Table 6. The data are a composite of both Corps of Engineers and Bureau of Sport Fisheries and Wildlife (from the Upper Mississippi River wildlife and fish refuge) visitation compilations for that year. In addition to being the most accurate data available to date, they are the most usable since visitation survey estimates were broken down to show ratios of participation in the seven most appropriate activities on an annual peak month basis. Total annual visitation to Pool 10 in 1963 was estimated at about 150,000, which represents the equivalent of about 1.7 visits for each of the 90,000 people residing in the zone of influence (St. Paul District, April, 1968).

Table 6 - Pool 10 total visitation - 1963

Activity	Annual 1963		Peak periods		
	Percent of total	Activity participation	Percent of total	Activity participation Month (Jul)	Activity participation Peak Day
Camping	2.7	4,050	3.2	1,250	95
Picnicking	5.3	7,950	5.2	2,030	155
Boating	23.3	34,950	30.0	11,700	885
Fishing	58.5	87,750	54.8	21,370	1,615
Water Skiing	2.0	3,000	3.2	1,250	95
Swimming	2.2	3,300	3.6	1,400	105
Subtotal	94.0	141,000	100.0	39,000	2,950
Hunting	6.0	9,000		5,850 (Oct)	440 (Oct)
Total annual	100.0	150,000			

Source: St. Paul District of the U. S. Army Corps of Engineers. April, 1968. Page 21.

Visitation during the peak month of July, 1963 was estimated at about 39,000 or more than 25 percent of the annual visitation. Table shows a breakdown of total annual, peak month, and peak day visitation by activities. Visitation for hunting is included with other visitation under the annual category only since this activity does not occur in the summer months and does not influence determination of summertime peak loads. It is estimated that about 65 percent of the total visitation shown in Table 6 is generated at or through available public-use sites. With the possible exceptions of camping and picnicking, the other five activities cited in Table , which account for 92 percent of the total participation are water-related. It seems reasonable to conclude that the higher, stable water level in Pool 10 resulting from the construction of Lock and Dam 10 has had a favorable impact on these five activities. In addition the dredge spoil that has had a detrimental effect on fishing has had a positive valvue for camping and picnicking activities.

Another source of data on sport fishing is availabe because attendants at each lock and dam make daily observations at 3:00 p.m. each day throughout the year of the num r of sport fishermen observed from their work location. Annual data for the most recent years for which these records are available in Table 7 . The table shows a wide variation in sport fishermen observed from Lock and Dam 10 since 1963. Because most sport fishermen observed from a lock and dam are downstream from the dam, most of the fishermen seen from Lock and Dam 10 are in Pool 11. Numbers of fishermen in Pool 10 -- as seen from Lock and Dam 9 have been

Table 7. Number of Sport Fishermen Observed Annually by Both Attendants From Lock and Dam Sites of Both Ends of Pool 10 on the Upper Mississippi River, 1960-1970.

Year	Lock and Dam 9	Lock and Dam 10
1960	11,997	8,214
1961	10,777	7,693
1962	9,648	8,266
1963	12,208	7,271
1964	11,478	7,315
1965	Not Available	Not Available
1966	Not Available	Not Available
1967	12,404	6,781
1968	13,846	6,811
1969	9,187	8,108
1970	10,327	5,750

Note: Counts are made once each day at 3:00 p.m.

Source: U. S. Corps of Engineers data published in the Proceedings of the Annual Meetings of the Upper Mississippi River Conservation Committee, 1960-1971.

substantial, averaging about 11,000 from 1960. This value of fishing indicates the recreational importance of this pool and the entire lower stretch of the river as a recreational resource.

In terms of impact on sport fishing the higher water level in Pool 10 has increased the spawning areas for fish. In theory this offers the potential for more sport fishing. However, the potential both for increased commercial and sport fishing in Pool 10 may be partially offset by river pollution and turbidity from barge activity in it. Also in recent years improper dredge spoil placement has reduced the acreage of available fish habitat in Pool 10, and sedimentation has also hurt fish habitat -- particularly in areas below wing dams. Therefore, Corps' operations following the construction of Lock and Dam 9 have had both positive and negative effects on fish (and also waterfowl) habitat in the pool.

As the water levels in Pool 10 was raised by Corps' operations, habitat for residential and migratory waterbirds was initially increased. As with fish habitat, improper dredge spoil placement in recent years has also reduced waterfowl habitat. This suggests the potential for greater bird hunting adjacent to Pool 10. Some measure of hunting activity in the pool is shown in Table that notes 9,000 hunting visits to Pool 10 in 1963.

Recreational sites along the perimeter of Pool 10 also facilitate sightseeing, picnicking, hiking, and camping. While non-boating visitors

to these sites might be there whether Corps' operations existed on the Upper Mississippi or not, virtually all of the activities at these sites by boaters are attributable to Corps' activities. In addition, visitors to overlooks at locks and dams are a direct result of Corps' operations.

Cultural Impacts

Conversations with the State Archaeologists for Iowa and Wisconsin (McKusick and Freeman, personal communications) revealed limited evidence of cultural impacts on sites in Pool 10 through the activities of the Corps of Engineers. Difficulties involved in identifying archaeological sites that may have been affected by Corps' operations are discussed in Appendix B.

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4. ANY ADVERSE ENVIRONMENTAL EFFECTS WHICH COULD NOT BE AVOIDED AS THE PROJECT WAS IMPLEMENTED

NATURAL SYSTEMS

The unavoidable effects are a result primarily of the construction of the wing and closing dams and Dam No. 10. Since the operation and maintenance activities can be modified they will not be included in this section.

The three major effects are: the destruction of terrestrial habitat and conversion of aquatic habitats as a result of the increase in water level, the reduction in the flow rates of portions of the river, and the modification of the rate and the locations of sedimentation.

Pool Raise

The formation of the pool behind the dam resulted in the destruction of 7,800 acres of terrestrial habitat. 2,000 acres developed into lake area, the remainder became slough area.

Reduction in Flow Rates

The construction of Dam No. 10 resulted in a decrease in flow rates in that portion of the channel in which the navigation pool formed. This reduction in rate resulted in a habitat change from a river-like condition to a lake environment. Fish populations, especially small mouth bass and paddlefish decreased since they do best in gravel run areas of the river. The placing of closing dams on side channels reduced flow below the dam changing the water quality and temperature of the backwaters.

Sedimentation

The formation of the wing dams created a series of sediment traps along the main channel and produced an environment which will continue to fill in with sediment until the entire area behind the wing dam is terrestrial. The reduction in flow along the main channel increased the sediment load deposited in the channel and developed a self-perpetuating problem which seems to require continued dredging. The broad backwater lakes with little or no flow act as traps for the finer sediments and they seem to be filling in with silt and clay deposits.

Indirect Effects

As a result of the improvement in navigation there was an increase in urban, agricultural, and industrial development. This resulted in increased *sediments* load caused by increasing erosion, and the destruction of terrestrial environment by construction of roads and buildings.

5. ALTERNATIVES TO THE PRESENT OPERATIONS AND MAINTENANCE ACTIVITIES AND FACILITIES

CHANNEL MAINTENANCE

Since the major continuing problem in most pools is concerned with dredge spoil, alternative methods to alleviate present conditions are needed. Some alternatives include the following.

Dredging Frequency

Dredge whenever the channel depth is reduced by a fixed amount, such as one foot. This would reduce the amount of spoil produced in any one year, but it would not reduce the accumulation over a period of time, so the total spoil deposited would remain the same. This would increase the cost of dredging and might increase the environmental impact. A major problem with spoil is the tendency to erode back into the river because it is not stabilized with vegetation. Continual deposition of spoil would tend to slow up recolonization of the spoil banks and increase the tendency to erode. The problem of resuspension of fine particles and toxic substances which have settle out onto the bottom would be increased by more frequent dredging.

Dredge Spoil Disposal Conferences

Survey the proposed dredging areas annually with representatives from BSF&W and other interested groups, to determine deposition sites. This is being done at present and it must be continued as the best first step in solving the problem. However to be effective the initial survey of bottom profile and the determination of dredge sites must be carried out early

enough to allow for effective input from interested groups. The Conference in 1973 had limited value since specific sites had not been developed by the Conference date.

Equipment Improvement

Lengthen spoil lines and increase pump capacity to permit deposition at greater distances from the dredge. It would be necessary to modify Dredge Thompson, purchase a new dredge or contract for the dredging. This would increase the number and location of possible spoil sites but in itself would not improve the present situation.

Removal of Spoil from Floodplain

Encourage beneficial uses of dredged materials by communities or industries in the Mississippi Valley. The BSF&W have completed a recent survey (Anonymous 1973) which suggests that there is a market. Water worn sand and gravel makes the best aggregate for concrete (USDI, 1966). The spoil would have to be deposited at collection points readily accessible to surface transportation, or barges for hauling from the primary deposit site would be required. On a long term basis this plan of removal from the flood plain offers the greatest environmental benefit.

Control of Sediment Deposition

Add new structures or modify existing ones to control deposition of bed load in the channel at locations with ready access to markets for the spoil. The present areas of maximum deposition are determined by current pattern, the sediment load of tributaries, and existing wing dams. Current patterns and wing dams could be modified for the specific purpose of

controling sedimentation. This is particularly true in the lower 1/3 of the pool where the dam is the primary control structure of water level for navigation, and the wing dams have little positive function.

Annual Dredge Spoil Volume

Erosion Control

Erosion of the uplands result in the majority of sediment that is deposited in the channel. Soil conservation practice in the agricultural areas and in urban construction sites could reduce the sediment load.

Spoil Stabilization

Stabilize the spoil banks to prevent movement back into the channel. The primary problem in revegetation of the spoil banks seem to be the time of dredging. The two primary species which colonize and stabilize islands are willow and cottonwood. Willow spreads by underground sprouts and could spread into the spoil banks after deposition. However the willows require continuously saturated soil and the dry, arid conditions of the dredge spoil banks prevent their growth. Cottonwoods, which are drought resistant,are spread primarily by seed which is released in May. This is ideal for invasion of natural islands formed by receding floodwater which occur at the time of seed dispersal, but no seed is available when the dredge spoil banks are formed. As a result erosion can occur throughout the summer, fall, and during the spring floods before seed will be produced. Work needs to be done to circumvent this problem. An additional problem results from the disposal of spoil in closed canopy woodlands. While many of the mature trees can withstand partial burial, the understory

is destroyed and the combination of shade and dry sandy substrate, well above normal flood levels, is very difficult to recolonize.

Improvement Dredging

With the expansion of the Corps responsibility from navigation to the total river environment, dredging to improve habitat outside the channel should be considered. The opening or deepening of side channels or sloughs, especially in the lower ½ of the pool, could improve large areas of fish and game habitat. Backwater dredging to deepen existing lakes or ponds could also be carried out. This was done just below French Island at Guttenberg in the process of constructing the flood wall.

DAM OPERATION

As discussed in section 3, the formation of Pool 10 is different from all the other pools in the St. Paul District in relation to the location of the marsh habitat. The extension of the marsh to within four miles of the dam causes any fluxation in level to have drastic impact on the vegetation, fish, and game. The reduction of drawdow to one foot in 1971 was a positive step to relieve this problem but the possibility of reducing the drawdow to zero, as is done in Pool 7, and also in Pool 11 in the Rock Island District, should be considered.

An alternate approach would be to bring the operation of Dam 10 into conformity with the rest of the St. Paul District by maintaining primary control at the hinge point. This would have a similar effect to reducing drawdown since it would prevent the present program of short term flooding of the hinge point area during rising and falling stages.

LOCK OPERATION

The lock operation causes no problems with the natural environment.

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6. THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Resource Implications for Socioeconomic Activities

Table 8 summarizes the major resource implications of continuing to operate and maintain the nine-foot channel in the St. Paul District. Resource implications for these four groups are discussed in sequence below.

Corps' Operations

Table 6-1 identifies the major first order direct benefits associated with lock and dam operation and dredging operations. These include employment in lock and dam and dredging operations, maintenance of relatively controlled water levels in each pool, and the presence of a navigable nine-foot channel in the St. Paul District. About 150 people are involved with lock and dam operations in the district and about 75 with dredging operations; thus about 225 people derive jobs and income directly from Corps' operations. The annual direct cost to taxpayers for lock and dam operations (F.Y. 1970) is $2,601,000 and for dredging operations is $1,200,000. Specific environmental costs of the controlled water levels in the pools and the nine-foot channel in the St. Paul District are an increase in sedimentation behind dams and wing dams, and a reduction in fish and waterfowl habitat due to improper dredge spoil placement.

Table 8. First-Order Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-Foot Channel

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
[illegible] Operations	Lock and Dam (L/D) Operation	1. L/D employment. 2. Stable water levels	1. Cost of L/D operation 2. Sedimentation behind dams and wing dams.
	Dredging Operations	1. Dredging employment. 2. 9-foot channel	1. Cost of dredging operation 2. Destruction of fish and wildlife habitat due to improper dredge spoil placement.
Industrial	Barge Operation	1. Barge employment. 2. Low-cost water transportation. 3. Energy saving compared to alternate transportation modes.	1. Increased river turbidity. 2. River pollution from oil and gasoline from barges.
	Commercial Dock Operation	1. Dock employment. 2. Attraction of barge transportation oriented firms that provide local employment.	1. Increased river pollution from industrial activities along shore.
	Commercial Fishing and Trapping	1. Increased employment of fishermen and trappers. 2. Increased number of fish and pelts available for consumers.	
Recreational	Boating Activity	1. Increased recreational opportunities for boaters.	
	Operation of Recreational Facilities	1. Increased employment and business opportunities for facilities serving recreational users of the river (boaters, sport fishermen and hunters, etc.)	

Table 8. First-Order Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-Foot Channel (Continued)

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Recreational (Cont.)	Sport Fishing	1. Initially increased habitat for fish.	1. Increased sedimentation in fish habitat. 2. Decreased fish habitat from improper dredge spoil placement.
	Sport Hunting	1. Initially increase habitat for waterfowl.	1. Decreased waterfowl habitat from improper dredge spoil placement.
	Sightseeing, camping picnicking, swimming, water skiing	1. Improved opportunities for miscellaneous recreational activities.	
Cultural	Archaeological Sites		1. Loss of selected sites due to L/D construction and rising water.
	Historical Sites		1. Loss of selected sites due to L/D construction and rising water.
	Contemporary Sites		1. Loss of selected sites due to L/D construction and rising water.

Industrial Activities

As summarized in Table 8, the major direct impacts of Corps' operations on industrial activities are for barge operations, commercial dock operations, and commercial fishing. Table 8 notes that there are employment implications for each of these three activities but these benefits must be balanced against accompanying increases in sedimentation, turbidity, and possibly other pollution in the river.

Of special importance in the current energy crisis are the answers to two questions that relate to barge transportation: How effective is barge transportation relative to other modes of transportation with respect to:

1. Energy usage?
2. Air pollution?

Because the answers have major resource allocation implications for the Upper Mississippi River, these two questions are analyzed below in some detail. In addition savings in transportation costs due to barge movements are discussed.

Barge Transportation and Energy Usage. Effective energy utilization is particularly important due to the present (and probably continuing) energy crisis. It also affects air pollution which relates directly to transportation energy consumption.

At present transportation utilizes about 25 percent of the total U.S. energy budget for motive power alone. This usage has been increasing

at an average annual rate of about 4 percent per year.

In comparing the efficiency of energy utilization between various transportation modes the term "energy intensiveness" is commonly used. Energy intensiveness is defined as the amount of energy (in BTU's) needed to deliver one ton-mile of freight. The following table compares the energy intensivness of various modes of freight transportation (Mooz, 1973):

Freight	Energy Intensiveness (BTU's/ton-mile)	Ratios of E.I.
Waterways	500	1
Rail	750	1.5
Pipeline	1,850	3.7
Truck	2,400	4.8
Air Cargo	63,000	126

It is apparent from this table that motive energy is utilized more efficiently in water transportation than through any other mode of freight transportation. Therefore under conditions of restricted petroleum energy availability the use of barging wherever feasible should be encouraged. Indeed, an increased use of the Upper Mississippi and its tributaries is likely. Influencing this will be increased shipments of grain out of the St. Paul District and increased imports of coal and petroleum products into the region. Exports of grain to other countries and shipments to other parts of the U.S. are expected to increase. Energy demands in the Upper Midwest are also expected to rise. In addition freight which is now only marginally involved in barging may shift from other forms of transportation to the less energy-intensive forms. This shift may also be expected to change

existing concepts of the kinds of freight suitable for barging with consequent impact on storage facilities. In many cases economic trade-offs may exist between the mode of transportation and the size of inventories considered to be suitable. If the costs energy rise sufficiently, increased capital necessitated by use of the slower-moving barge transportation and tied up in inventory and in storage space may be justified. If this occurs, other kinds of cargoes presently shipped by rail or truck or pipeline may be diverted to barge.

In addition to energy conservation, the importance of the Upper Mississippi as a transportation artery is shown by the burden which would be placed on the rail system (as the major alternative transportation mode used to move heavy, high-bulk commodities) in the absence of barge traffic on the river. In 1972 an estimated 16,361,174 tons of various commodities were received and shipped from the St. Paul District. Under the simplifying assumption that the average box or hopper car carries 50 tons, this amounts to the equivalent of 327,223 railroad cars or some 3,272 trains of 100 cars each or approximately nine trains each day of the year.

Barge Transportation and Air Pollution. Barge transportation also results in less air pollution per ton-mile than either rail or truck modes. Diesel engines are the most common power plants used by both tugboats and railroads. A large percentage of over-the-highway trucks use diesel engines as well. The diesel engine is slightly more efficient than the gasoline engine due to its higher compression ratio. Thus, less energy is used to move one ton of freight over one mile by diesel than by gasoline engines.

Among users of diesel engines, barging is more efficient than either rail or truck, as we have seen. Consequently a smaller amount of fuel is required to move freight. With less fuel used, air pollution is reduced.

The amount of air pollution caused by either diesel fuel or gasoline varies substantially only in the type of air pollution. The following table illustrates these pollution effects (U.S.P.H.S., 1968):

Type of Emission	Emission Factor: Pound/1,000 gallons diesel fuel	Emission Factor: Pounds/1,000 gallons gasoline
Aldehydes (HCHO)	10	4
Carbon monoxide	60	2300
Hydrocarbons (O)	136	200
Oxides of Nitrogen (NO_2)	222	113
Oxides of Sulfur (SO_2)	40	9
Organic Acids (acetic)	31	4
Particulates	110	12

Based upon the energy intensiveness ratios shown earlier, a diesel train will produce 1.5 times as much air pollution and a diesel truck 4.8 times as much air pollution per-ton-mile as a tug and barges. In any event, no matter which kind of pollutant is of concern in a particular case, the efficiency of barging compared with other modes of freight transportation will result in reduced air emissions per ton-mile.

Barge Transportation and Cost Savings. A further benefit which can be attributed to the maintenance of navigation on the Upper Mississippi is

in the savings in transp... ion costs, particularly for bulk commodities. Estimates of these savings have been made. One of these estimates the savings over the other various least cost alternatives of between 4.0 and 5.4 mills per ton-mile (UMRCBS, 1970). It is generally recognized that bulk commodities, particularly those having low value-to-weight ratios, are appropriate for barge transport. Coal, petroleum, and grain that have these characteristics are examples of such commodities that originate, terminate, or move through the St. Paul District pools on river barges.

Recreational Activities

Table 8 identifies the variety of recreational activities -- from boating and sport fishing to sightseeing and camping -- that may be helped or hindered by Corps' operations. Ideally it would be desirable to place dollar values on each of the benefits and costs to the recreational activities cited in Table 8 to weigh against the benefits of barge transportation made possible by maintaining the nine-foot channel. Unfortunately both conceptual problems and lack of precise data preclude such an analysis. The nature of these limitations can be understood by (1) looking initially at a theoretical approach for measuring the benefits and costs of recreational activities and (2) applying some of these ideas to the measurement of only one aspect of all recreational activities -- sport fishing.

Benefits and Costs of Recreational Activities. Theoretical frameworks exist to perform a benefit-cost analysis of a recreation or tourism activity. One example is a study prepared for the U.S. Economic Development Administration (Arthur D. Little, Inc., 1967). Unfortunately even

this example closes with a "hypothetical benefit-cost analysis of an imaginary recreation/tourism project" that completely neglects the difficulty of collecting the appropriate data.

Applying even this theoretical framework to the nine-foot channel project presents both conceptual and data collection problems. For example, continuing to operate and maintain the nine-foot channel may hurt sport fishing because of the reduction in fish babitat. This means that the total value of sport fishing in the river should not be considered in the analysis. Rather, only the incremental increase or decrease in sport fishing attributable to present Corps' operations (not due to the initial lock and dam construction) should be weighed against those operations; no estimates are presently available to assess the effect of current Corps' operations on fish and wildlife.

This raises a second difficulty: How does one measure the total value of sport fishing on the river in order to start to measure the incremental portion attributable to Corps' operations? For sport fishing various measures have been identified, each having its own drawbacks (Clawson and Knetsch, 1966); gross expenditures by the fishermen, market value of fish caught, cost of providing the fishing opportunity, the market value as determined by comparable privately owned recreation areas, and the direct interview method -- asking fishermen what hypothetical price they would be willing to pay if they were to be charged a fee to fish.

If some average price per fisherman or trip were available, it still would be possible to assess the total value of sport fishing in the study

area only if estimates of the number of sport fishermen or number of sport fishing trips were available. In the St. Paul District these estimates are available through sport fishery surveys for only three pools: Pool 4, Pool 5, and Pool 7. The most recent data available for these pools are for the 1967-68 year (Wright, 1970): comparable data for 1972-73 have been collected but are not expected to be published in report form until about December, 1973.

Valuing Sport Fishing in the Study Area. A variety of studies have been done on recreation and tourism in Minnesota and the Upper Midwest during the past decade (North Star Research Institutue, 1966; Midwest Research Institutue, 1968; Pennington, et al., 1969). For purposes of analyzing sport fishing and other recreational activities on the Upper Mississippi River, however, they have a serious disadvantage; these studies are generally limited to recreationers who have at least one overnight stay away from home. In the case of the St. Paul District, with the exception of campers and boaters on large pleasure craft with bunks, virtually all river users are not away from home overnight and are omitted from such studies.

Information is then generally restricted to that available in the UMRCC sport fishing studies such as those shown below for 1967-68 (Wright, 1970):

Pool Number	Total Number of Fishing Trips	Value of $5.00 Per Trip[a]	Value at $1.50 Per Trip[b]
4	169,361	$846,805	$254,042
5	51,786	258,930	77,699
7	63,238	316,190	94,857

[a]Based on data reported in the "1965 National Survey of Fishing and Hunting" that the average daily expenditure for freshwater sport fishing was $4.98 per day.

[b]Based on data in Supplement No. 1 (1964) to Senate Document 97 that provides a range of unit values of $0.50 to $1.50 a recreation day for evaluating freshwater fishing aspects of water resource projects.

Thus the sum of the values of sport fishing given above for these three pools varies from about $0.4 million to $1.4 million depending upon the valuation of a fishing trip. Assuming one of these values were usable, the researcher is still left with the task of determining the portion (either as a benefit or cost) of Corps' operations. With the limited funds available for the present research and the limited existing data, detailed analysis is beyond the scope of the present study.

Similar problems are present in evaluating the other recreational activities in the study area.

Cultural Sites

No attempt has been made in the present study to place dollar values on archaeological, historical, or cultural sites damaged or enhanced by Corps' operations. Rather, such sites have merely been identified, where existing data permit. However this does not suggest that there is no loss, there is an incalcuable loss with distruction of irreplacable sites.

The present uses of the Upper Mississippi River based on the priorities of the Corps responsibilities in the past is heavily oriented to navigation, with other uses permitted as long as they did not hinder the primary position of navigation.

As pointed out in the Main Report of the Upper Mississippi River Comprehensive Basin Study the region of the Upper Mississippi River including Pool 10 is ranked as the second in the priority listing of problem areas in the basin in the period up to 1980. The problem areas are in water quality, recreation and commercial navigation improvements, flood and sediment damage and environment preservation. This diversity of problem areas indicates that single purpose planning is no longer a valid approach to long term productivity of an area. With increasing demand for water related recreation it becomes increasingly important to retain optimum quality of the natural setting in regions like Pool 10 where urban and industrial disturbances have been limited. The UMRCBS report located four aesthetic/cultural nodes in pool 10, these are areas where natural and cultural resources cluster, and indicated that they were areas worthy of preservation and enchancement. This is the greatest number of aesthetic/cultural nodes in an individual pool in the St. Paul District.

In planning short term operations and maintenance, it must be recognized that sedimentation, cannalization, and disturbance of natural sites produces irreversible changes which effect long term productivity.

For continued long productivity and increased stability of the resources future operations and maintenance carred out in the 9 foot channel project in Pool 10 must optimize and enhance all favorable factors. This will require modifications of the present program which is primarily navigation oriented, but seems well within the scope of the Corps of

Engineers Environmental Policy, issued in June 1970, which indicated a commitment to balance the nation's developmental and environmental needs.

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7. IRREVERSIBLE COMITMENTS OF RESOURCES WHICH HAVE BEEN INVOLVED IN THE PROJECT SINCE IT WAS IMPLEMENTED

RESOURCES LOST, INCLUDING LAND USE CHANGES

The land, materials and labor used in the direct construction of the Corps' facilities in Pool 10. This includes extensive quarrying in the area for construction of the wing dams, and closing dams.

The labor and equipment necessary for maintenance of both the lock and dam, and for continued dredging of the channel.

The conversion of 7,800 acres of terrestrial woodland and cropland into aquatic habitat, converting agricultural land to land primarily used in recreation. The modification of 36.1 miles of river by manipulation for navigation interests; including maintaining water levels, decreasing fluctuation of the upper regions of the pools, and decreasing species diversity.

8. RECOMMENDATIONS

DREDGE SPOIL

The continued maintenance of a nine foot navigation channel will require continued dredging to maintain minimum depth in all areas of the channel. The following actions are recommended to alleviate the diverse problems arising from dredging.

1) Watershed Stabilization

Support and promote action on a local or state level to encourage or require soil conservation and stabilization practices on all watersheds which drain into impounded rivers or streams. As long as erosion continues dredging will continue to be a treatment rather than a solution to the problem.

2) Dredge Spoil Placement Planning

Continue and increase the coordination between the dredge operator and the project planner and the BSF&W personnel and other interested groups along the river. Until more efficient means of disposal are developed, cooperation between the Corps and the environmental interests can mitigate future damage.

3) Stabilization of Spoil Banks

Conduct studies on natural stabilization of spoil banks, to develop methods of encouraging natural revegetation, and efficiently planting stabilizing vegetation. This would retard redeposition of spoil into the river during high water and improve the aesthetic effect, and recreational potential of spoil sites.

4) Disposal of Spoil Material Outside of Floodplains

All the above are either long term projects (No. 1) or short term stop gaps (No. 2,3). The only efficient technique seems to be the removal of materials from the floodplain. We recommend an expansion of the 1973 survey by the BS&W to locate markets for the spoil in the vicinity of each pool, and further studies to develop efficient techniques for transporting dredge spoil to shipping locations.

5) Improvement Dredging

In response to the expanded role of the Corps to total environmental interests, rather than just navigation, begin a program of improvement dredging in Pool 10 to enhance recreational usage and expand access to fishing areas. A possible starting list would include: (Master Plan for Resource Management - Part XII - Pool 10).

Approximate mile	Crawford County
646	Gordon's Bay - Dredging to open a channel into Gordon's Bay.
642	Upper end of the Ambro Slough - Removal of rock fill (about 50 ft) and dredging.
636	Sunfish Lake - There is need for dredging of a channel to deepen the entrances into Sunfish Lake.
633	McGregor Lake - The existing channel into this lake needs deepening so as to provide access for hunting and fishing.
	Grant County
629	Lower end of Glen Lake or the upper end of Wyalusing Bay - Present channel is not adequate for boat traffic.
626	Upper end of Catfish Slough - Deepen existing channel into head end of Catfish Slough.
623	Ferry Lake - Deepen entrance.
621	Railroad track slough below Sandy Creek - Needs about 150 yards by 20 yards of channel deepened.

616 Ott's Lake - Deepen channel for a distance of 150 yards to Stateline Slough.

These projects would provide additional or improved access to the main channel and the work would consist of dredging new openings, enlarging and deepening existing channels and removing old closing dams.

DAM OPERATION

Elimination of Drawdown in Pool 10

Since the topography of Pool 10 is unique in the St. Paul District, and since fluctuations in water level are particularly damaging to aquatic marsh vegetation, fish and wildlife, and since this habitat extends to just above Dam 10 we recommend that serious study be given to the feasibility of reducing the drawdown to zero. This Limitation is present in Pool 7 and in several pools in the Rock Island District. If it can be done without jeopardizing navigation interest, it would definitely improve the aquatic habitat in Pool 10.

Modification of Operation Plan

A possible alternate approach would be to redesign the operating plan of Pool 10 and bring it into conformity with the other Pools in the St. Paul District. The shifting of the primary control point to Clayton and the resulting stabilization of the water level in the Clayton - Bagley - Frenchtown lake region which would result should do much to mitigate the problem of water fluctuation.

COMPILATION AND PUBLICATION OF FIELD STUDIES

The initial impression from the literature is that little work has

been done on the Upper Mississippi River. Investigation reveals a mass of investigations and reports in mimeograph form that have been circulated within agencies but are not readily available to the scientific community. We recommend that the Corps of Engineers in cooperation with the BSF&W compile this information into a data bank and develop procedures to either publish it or make it available, with proper safeguards for recognition of the origin of the work, to interested and qualified researchers. This present study and the bibliography by Helm and Boland (1972) are important first steps, but further utilization and coordination of this data must be encouraged.

Reference

Corps of Engineers. 1968. Master Plan for Resource Management Part XII - Pool 10. Department of the Army

Helms, Don and Tom Boland. 1972. Upper Mississippi River Natural Resources Bibliography. Fish Technical Section, Upper Mississippi River Conservation Committee.

GLOSSARY

anerobic	the lack of oxygen in a particular environmental setting.
benthic	the bottom region in a body of water which is too deep for rooted green plant growth because of lack of light penetration.
cfs	cubic feet per second-velocity of water flow.
humus	the surface layer of soil combining partially decomposed organic matter and mineral particles.
littoral	the bottom zone in a body of water which is shallow enough to receive sufficient light to allow green rooted plants to survive.
mesic	a type of vegetation which develops under ideal moisture conditions.
plankton	microscopic, free-floating plants and animals drifting in the water.
podzolic	grey-brown acid soil developing under oak forest. A result of leaching by water which removes soluble minerals.
Thermocline	a layer in a body of water where the temperature during the summer drops rapidly (more than 1 C per meter).
till	rock, sand, and gravel deposited by the melting of glacier ice.
weathering	the long term geologic process resulting from the erosion of the landscape.

9. APPENDIX A

ACKNOWLEDGEMENTS

The help of Dr. Gerald Kaufmann who developed the portions of this study dealing with fish, waterfowl, and wildlife, is gratefully acknowledged. The Socioeconomic portion of this study was written by Dr. W. Rudelius and Dr. W. Schwarz, North Star Institute. I would also like to recognize Mr. Duane Jasper and Mr. John Hartman, research assistants on the study.

NATURAL SYSTEMS

Three transects across the valley from the terrace on the east to the terrace on the west were laid out. Transect A-A' is located at the upstream end of Pool 10 starting at the pole at end of the tower guide wall, the permanent location point, and running at an angle of 310° for 1.87 miles to the Milwaukee Road tracks on the west side of the valley. (Figures 20,21)

Transect B-B' is located at the primary control point at Clayton, Iowa. The government light at mile 624.6 is the permanent location point and the transect runs at an angle of 55.5° for 1.67 miles to the C. B. & Q. R. R. on the east bank of the river. (Figures 20, 22)

Transect C-C' is located just above Lock and Dam No. 10. The permanent location point is the light tower at the end of the upper guide wall and transect runs at an angle of 57.5° for 1.33 miles to the C. B. & Q. R. R. on the east bank of the river. (Figures 20,23)

In addition two special transects will be sampled to evaluate the effect of the Wisconsin River on the Pool 10. (Figures 20, 24)

Transect Z-Z'will cross the Wisconsin River approximately 100 yds. upstream of the C. B. & Q. R. R. for a distance of .27 miles. Initial sampling indicated that no discernable effect was apparent with the present level of investigation, so sampling along the transect was terminated.

Transect Y-Y'will cross the Mississippi just above the confluence of the Wisconsin River. The permanent location point is the government light north of the Wisconsin River; the transect runs at an angle of 73° a distance of 1.75 miles to the C. B. & Q. R. R. on the east bank of the river.

Water temperature, turbidity, oxygen, orthophosphate, nitrate, nitrite and benthic invertibrates was sampled twice between the end of flooding and the fall. The aquatic macrophytes and the terrestrial vegetation will be sampled along the four transects.

The plankton was sampled in August at Prairie du Chien to compare present populations with the data recorded by Galtsoff in 1924.

METHODS

In the aquatic sampling the following methods was used:

1) Water samples will be obtained with a 1 liter Kenmerer bottle.
2) Oxygen and water temperature will be sampled using a YSI oxygen probe Model 51A.
3) Turbidity will be sampled using a Hach Model 2100 Tubidimeter.
4) Orthophosphate and nitrate-nitrite will be sampled using the Hach Model DR-EL.

5) Benthic invertebrates will be sampled using a Echman dredge.

The mapping was carried out using a Brunton compass, Sunto inclinometer, surveyors chain, range finders, and a Herters Fish Finder model 125D for depth measurements.

Vegetation Sampling

The sampling of terrestrial and rooted aquatic vegetation in this project is complicated by several factors. The diversity of the stand types, their variable size and the repetitive nature of the stands due to the complexity of the bottomlands. The broad geographic scale and the time limitations indicate the need for rapid survey methods, and yet the permanent transects dictate the importance of good base line description of the communities.

The initial measurements in all cases will be the intercept of the vegetational zones along the transect. The beginning and end of each zone will be recorded for use in mapping zonal types. Following this the individual types will be sampled, generally at right angles to the main transect.

The herbaceous terrestrial plants will be sampled in 10, 1/2 by 2 meter quadrats, the long axis running parallel to the river. Only the presence of species will be recorded in each quadrat to calculate frequency. No species counts will be made.

Shrub and woody seedlings (trees up to 1 in. in D.B.H.) will be sampled using 5 quadrats 1 by 5 meters. The herbaceous quadrats will be placed in opposite corners of these quadrats.

In forest stands the quarter method (Cottam and Curtis, 1956) will be used. 20 points will be sampled on one or more stratified random lines at right angles to the transect. Both trees and saplings will be recorded. The shrub and herbaceous quadrats will be set up at every four points.

Due to the difficulty in differentiating between silver and red maple along the river due to apparent hybridization (Ware 1955) it was decided to consider them a complex and no attempt was made to differentiate the two species. They will be called *Acer sacharinum* in the present study.

The aquatic communities, will be sampled using belt transects 100 feet long divided into 10 - 1 x 10 foot quadrats.

RESULTS

The values for water quality (Table 9) were well below the pollution guide lines with the exception of phosphate, which regularly exceeded the FWPCA guideline of .05mg/L in Transects A, B, and Y. In each case the high readings were in backwater areas. The turbidity reading, taken during stable water conditions in August showed uniformly low values.

PLANKTON

Dr. P. Galtsoff in his 1921 survey of the Mississippi river (1924) recorded the following data in the east channel of Prairie du Chien on August 15; plankton volumne - 32 cc/m^3, Copepoda - 17, 520 organism/m^3, Cladocera - 160 organism/m^3, transparency using a Secchi disk was 17 cm.

Table 9. Water Quality Measurement in Pool 10. - Summer 1973

Site		Nitrate (ppm)		Nitrite (ppm)		Phosphate (ppm) Ortho		Phosphate (ppm) Total		Turbidity (FTU)
Date		6/14	8/8	6/14	8/8	6/14	8/8	6/14	8/8	8/8
Main Channel		.19		.01		.11		.11		
Guttenberg	A		.16		.05		.20		.24	15
Transect	B		.22		.007		.23			18
A-A'	C		.20		.009		1.8			20
	D		.65		.007		.5			34
	E		.42		.001		.25		.26	17
	F		.09		.01		.25		.26	21
	G		.14		.045		.21		.23	19
	H		.13		.007		.34			16
	I	.16	.10	.01	.007	.08	.35	.10	.36	10
	J		.14		.001		.72		.72	14
Main Channel		.16		.01		.08		.08		
Clayton	A		.23		.004		.95			15
B-B'	B		.30				1.4			16
	C		.065		.001		.15			10
	D		.005		.001		.32			17
	E		.28		.001		.23			7
Main Channel		.10		.012		.0		.08		
Prairie du Chien	A		.20		.04		.95			15
Y-Y'	B		.092		.07		.41		.46	15
	C		.21		.015		1.1		1.6	20
	D		.15		.03		.75		.86	10
	E		.293		.001		.37		.40	32

Table 9. Water Quality Measurement in Pool 10. - Summer 1973

Site		Nitrate (ppm)		Nitrite (ppm)		Phosphate (ppm) Ortho		Phosphate (ppm) Total		Turbidity (FTU)
Date		6/14	8/8	6/14	8/8	6/14	8/8	6/16	8/8	8/8
Main Channel		.12		.008		.015		.01		
Lynxville C-C'	A		.005		.007		.07		.20	6
	B		.115		.007		.65		.69	15
	C		.15		.01		.41			11
	D		.148		.001		.67		.70	29
	E		.21		.01		.56		.56	11
	F	.10	.26	.009	.01	.1	.32		.43	43

on September 14. The dominant phytoplankton included: Melosira crenulata, Fragilaria crotonensis, Anabaena spiroides, and copopods. Clathrocystis aeruginosa, Microcystis sp. and Aphanizomenon flos-aquae were also important.

In a sample taken, in the same area on August 18, 1973 the following results were obtained: Plankton volumne 4.2 cc/m^3, Copepoda - 3,571 organism/m^3, Cladocera - 92 organism/m^3, and a Transparency of 55 cm. The dominant phytoplankton were Microcystis sp., Melosira crenulata, and Anabena flos-aquae.

While it is difficult to base any conclusion on this limited a sample it would seem that there has been a reduction in the plankton population with the development of the series of pools resulting from the 9 - foot project. This is the reverse of what would be expected and would merit additional investigation to examine if this decrease is, in fact, true, and if so to evaluate possible reasons for the decrease.

INVERTEBRATES

A comparison of the benthic invertebrates from the upper reaches of the pool with those from the inundated region just above the dam indicates that the flooding has resulted in a marked increase in productivity in the flooded areas. (Table 10) The population distributions from the benthic sample (Table 12,13 shows high diversity in the C-C' transect with decreasing diversity as we move north to the A-A' transect where the tubicicidae are the dominant organisms. Hexagenia, the large may-flies, are found in all four transects; the population in the A-A' transects was low in the June sampling but very high in the August, when the population consisted primarily of the new batch

Table 10. Biomass (Kg wet weight/hectar)

Guttenberg (C-C')

Site	A	B	C	D	E	F	G	H	I	J
Bottom type	Silt Organic Matter	Sand Silt	Clay Silt	Clay Silt	Silt	Sand Silt	Silt Organic Matter	Sand Silt	Silt Organic Matter	Sand Gravel
6/14/73	558	1032	327	192	54	92	2	1	491	3830
8/8/73	661	27	1750	1307	2566	690	1244	312	1773	125

Prairie du Chien (Y-Y')

Site	A	B	C	D	E
Bottom type	Silt Organic Matter	Silt Veg.	Silt Veg.	Silt Veg.	Silt
6/12/73	965	102	276	377	
8/9/73	950	52	243	151	343

Clayton (B-B')

Site	A	B	C	D	E
Bottom type	Sand Silt	Silt	Silt Organic Matter	Clay	Clay Silt
6/8/73	1	224	271	167	103
8/8/73	682	263	78	37	188

Lynxville (A-A')

Site	A	B	C	D	E	F
Bottom type	Gelatinous Clay	Gelatinous Clay	Gelatinous Clay	Gelatinous Clay	Gelatinous Clay	Silt Organic Matter
6/13/73	153	52	240	326	131	54
8/9/73	229	4.7	15	15	.7	805

Table 11.Mussel Fauna Listed in Study.

Fusconaia ebena (Ebony Shell or Niggerhead)
Megalonaias gigantea (Washboard)
Amblema plicata (Three-Ridge or Blue Points)
Quadrula quadrula (Maple-Leaf)
Quadrula nodulata (Warty-Back)
Tritogonia verrucosa (Buckhorn)
Arcidens confragosus (Rock Pocketbook)
Actinonaias ligamentina (Mucket)
Plagiola lineolata (Butterfly)
Ligumia recta (Black Sand-Shell)
Lampsilis anodontoides f. anodontoides (Yellow Sand-Shell)
Lampsilis anodontoides f. fallaciosa (Slough Sand-Shell)
Lampsilis ventricosa (Pocketbook)

Table 12. Benthic Invertibrates collected June 1973.
Values recorded in number per square meter.

	SITE: GUTTENBERG C-C' STATION A	B	C	D	E	F	G	H	I	J
Annelida										
Hirudinea										
Glossiphoniidae										
Helobdella stagnalis										
Placobdella montifera										
Glossiphonia heteroclita										
Erpobdellidae										
Erpobdella sp.										
Nephelopsis obscura										
Oligochaeta										
Naididae										
Nais variabilis										
Tubificidae										
Branchiura sowerbyi	387.5	215.3		129.2	215.3					
Limnodrilus claparedianus	4564.4	516.7	172.2	129.8	1421.0					172.2
L. hoffmeisteri	387.5					43.06				
L. udekeminanus	1808.5	129.2		43.06						43.06
Tubifex tubifex	818.1	172.2			258.4					43.06
Peloscolex multisetosus	43.06									
Arthropoda										
Crustacea										
Amphipoda										
Hyalella azteca			43.06							43.06
Isopoda										
Asellus mititaris			43.06		43.06					172.2
Insecta										
Diptera										
Ceratopogonida										
Chironomidae (Tendipes)		43.06	43.06	215.3	43.06	215.3	43.06			
Coelotanypus										
Cricotopus										
Chironomus (Crypotochironomus)										
Palpomyia		43.06			43.06					43.06
Polypedilum										

SITE: GUTTENBERG

	STATION A	B	C	D	E	F	G	H	I	J
Procladius										
Polypedilum										
Smitta										
Pelopiinae										
Pentaneura sp.	129.2	43.06	129.2	129.2	129.2				689.0	
Ephemeroptera										
Caenidae										
Caenis sp.										
Ephemeridae										
Hexagenia limbata	1162.6		43.06	258.4	215.3				1377.9	
Heptageniidae										
Stenonema										
Baetidae										
Ephemerelia sp.										
Odonata										
Dorosocrodulia sp.			86.12						129.2	
Agrionidae										
Agrion sp.										
Plecoptera										
Perlodidae										
Isoperia op.										
Tricoptera										
Hydropsychidae										
Cheumatopsyche										
Hydroptilidae										
Hydropolita										
Leptoceridae										
Mystacides sp.			172.2							
Leptocerus americanus										
Mollusca										
Gastropoda										
Pleuroceridae										

STATION

SITE: GUTTENBERG

	A	B	C	D	E	F	G	H	I	J
Heliosoma antrosa										
Valvatidae										
Valvata sp.	172.2	43.06		215.3	43.06		43.06		129.2	
Lymnaeidae										
Lymnaea sp.										
Viviparidae										
Campeloma sp.					172.2	43.06			172.2	
Viviparus sp.					43.06				43.06	43.06
Physaeidae										
Physa sp.										
Amnicolidae										
Amnicola sp.				301.4					129.2	
Pelecypoda										
Unionidae										
Megalonais gigantia										
Truncilla donaciformis										
T. Truntata										
Lampsila										
Utterbachia imbecilis		43.06								
Sphaeridae										
Sphaerium transversum	301.4	775.1	129.2	129.2	129.2		43.06	86.12	602.8	215.3
S. sulcalum						86.12				
Platyhelminthes										
Tubellaria										
Planariidae										
Dugesia trigrina			43.06							
Nemathelminthes										
Nematoda										
Diplogasteridae										
Diplogaster sp.										

SITE: CLAYTON B-B'	STATION A	B	C	D	E	F
Annelida						
Hirudinea						
Glossiphoniidae						
Helobdella stagnalis			43.06			
Placobdella montifera						
Glossiphonia heteroclita						
Erpobdellidae						
Erpobdella sp.						
Nephelopsis obscura					43.06	
Oligochaeta						
Naididae						
Nais variabilis						
Tubificidae						
Branchiura sowerbyi			129.2			
Limnodrilus claparedianus		172.2	430.6	1765.5	129.2	
L. hoffmeisteri						
L. udekeminanus		43.06	129.2			
Tubifex tubifex		43.06	861.2	516.7	732.0	
Peloscolex multisetosus				172.2		
Arthropoda						
Crustacea						
Amphipoda						
Hyalella azteca			473.7		43.06	
Isopoda						
Asellus mititaris			3272.6		43.06	
Insecta						
Diptera						
Ceratopogonida						
Chironomidae (Tendipes)		172.2	645.9	215.3	344.5	
Coelotanypus						
Cricotopus						
Chironomus (Crypotochironomus)						
Palpomyia		129.2		43.06	1421.0	
Polypedilum						

STATION

SITE: CLAYTON	A	B	C	D	E	F
Procladius						
Smitta						
Pelopiinae						
Pentaneura sp.		43.06	172.2	43.06	1507.1	
Ephemeroptera						
Caenidae						
Caenis sp.						
Ephemeridae						
Hexagenia limbata		387.5	129.2	129.2	43.06	
Heptageniidae						
Stenonema						
Baetidae						
Ephemerelia sp.			43.06		43.06	
Odonata						
Dorococrodulia sp.			43.06			
Agrionidae						
Agrion sp.			258.4			
Plecoptera						
Periodidae						
Isoperia op.						
Tricoptera						
Hydropsychidae						
Chiumatopsyche						
Hydroptilidae						
Hydropolita						
Leptoceridae						
Mystacides sp.						
Leptocerus americanus			43.06			
Mollusca						
Gastropoda						
Pleuroceridae						
Pleurocera acuta						
Heliosoma antrosa						

STATION

SITE: CLAYTON	A	B	C	D	E	F
Valvatidae						
Valvata sp.					301.4	
Lymnaeidae						
Lymnaea sp.		43.06				
Viviparidae						
Campeloma sp.						
Viviparus sp.	43.06					
Physaeidae						
Physa sp.			43.06			
Amnicolidae						
Amnicola sp.						
Pelecypoda						
Unionidae						
Megalonais gigantia						
Truncilla donaciformis						
T. Truntata						
Lampsila						
Utterbachia imbecilis						
Sphaeridae						
Sphaerium transversum		129.2	775.1		129.2	
S. sulcalum						
Platyhelminthes						
Tubellaria						
Planariidae						
Dugesia tigrina			215.3			
Nemathelminthes						
Nematoda						
Diplogasteridae						
Diplogaster sp.						

SITE: PRAIRIE DU CHIEN Y-Y'

	STATION A	B	C	D
Annelida				
Hirudinea				
Glossiphoniidae				
Helobdella stagnalis		129.2	43.06	43.06
Placobdella montifera				
Glossiphonia heteroclita				43.06
Erpobdellidae				
Erpobdella sp.				86.12
Nephelopsis obscura				
Oligochaeta				
Naididae				
Nais variabilis				
Tubificidae				
Branchiura sowerbyi				
Limuodrilus claparedianus	86.12	2153.0	1334.9	1507.1
L. hoffmeisteri				
L. udekminanus				86.12
Tubifex tubifex		43.06		129.2
Peloscolex multisetosus				43.06
Arthropoda				
Crustacea				
Amphipoda				
Hyalella azteca				
Isopoda				
Asellus mititaris		172.2	258.4	1291.8
Insecta				
Diptera				
Ceratopogonida				
Chironomidae (Tendipes)	258.4	172.2	1722.4	215.3
Coelotanypus				
Cricotopus				
Chironomus (Crypotochironomus)				
Palpomyia	86.12		129.2	
Procladius				

SITE: PRAIRIE DU CHIEN

	STATION			
	A	B	C	D
Polypedilum				
Smitta				
Pelopiinae				
Pentaneura sp.	129.2	387.5	559.8	43.06
Ephemeroptera				
Caenidae				
Caenis sp.				
Ephemeridae				
Hexagenia limbata	1076.5	43.06	43.06	129.2
Heptageniidae				
Stenonema				
Baetidae				
Ephemerelia sp.				
Odonata				
Dorococrodulia sp.				
Agrionidae				
Agrion sp.				
Plecoptera				
Periodidae				
Isoperia op.				
Tricoptera				
Hydropsychidae				
Chiumatopsyche				
Hydroptilidae				
Hydropolita				
Leptoceridae				
Mystacides sp.				
Leptocerus americanus				
Mollusca				
Gastropoda				
Pleuroceridae				
Pleurocera acuta				
Heliosoma antrosa				

SITE: PRAIRIE DU CHIEN

	STATION A	B	C	C
Valvatidae				
Valvata sp.	43.06	129.2	861.2	215.3
Lymnaeidae				
Lymnaea sp.				
Viviparidae				
Campeloma sp.				
Viviparus sp.	86.12			
Physaeidae				
Physa sp.				
Amnicolidae				
Amnicola sp.				86.12
Pelecypoda				
Unionidae				
Megalonais gigantia				
Truncilla donaciformis				
T. Truntata				
Lampsila				
Utterbachia imbecilis				
Sphaeridae				
Sphaerium transversum	516.7			
S. sulcalum				
Platyhelminthes				
Tubellaria				
Planariidae				
Dugesia tigrina				
Nemathelminthes				
Nematoda				
Diplogasteridae				
Diplogaster sp.				

SITE: LYNXVILLE A-A' STATION

	A	B	C	D	E	F	G
Annelida							
Hirudinea							
Glossiphoniidae							
Helobdella stagnalis							
Placobdella montifera						43.06	
Glossiphonia heteroclita							
Erpobellidae							
Erpobdella sp.							
Nephelopsis obscura							
Oligochaeta							
Naididae							
Nais variabilis							
Tubificidae							
Branchiura sowerbyi		43.06					
Limuodrilus claparedianus		1076.5	1464.0	818.1	1765.5	2885.0	
L. hoffmeisteri					43.06		
L. udekminanus		43.06	301.4		43.06	301.4	
Tubifex tubifex		172.2	215.3			129.2	
Peloscolex multisetosus							
Arthropoda							
Crustacea							
Amphipoda							
Hyalella azteca						43.06	
Isopoda							
Asellus mititaris							
Insecta							
Diptera							
Ceratopogonida							
Chironomidae (Tendipes)	86.12	172.2	86.12	258.4	43.06		
Ceelotanypus							
Cricotopus							
Chironomus (Crypotochironomus)							
Palpomyia		215.3	601.8	215.3	43.06		
Polypdeilum							

STATION

SITE: LYNXVILLE	A	B	C	D	E	F	G	H	I
Procladius									
Smitta									
Pelopiinae									
Pentaneura sp.	258.4	86.12	1334.9	172.2	43.06				
Ephemeroptera									
Caenidae									
Caenis sp.									
Ephemeridae									
Hexagenia limbata	1980.8	1765.5	1377.9	602.8	516.7				
Heptageniidae									
Stenonema									
Baetidae									
Ephemerelia sp.									
Odonata									
Dorococrodulia sp.									
Agrionidae									
Agrion sp.									
Plecoptera									
Periodidae									
Isoperia op.									
Tricoptera									
Hydropsychidae									
Chiumatopsyche									
Hydroptilidae									
Hydropolita									
Leptoceridae									
Mystacides sp.									
Leptocerus americanus									
Mollusca									
Gastropoda									
Pleuroceridae									

SITE: LYNXVILLE	STATION								
	A	B	C	D	E	F	G	H	I
Heliosoma antrosa									
Valvatidae									
Valvata sp.									
Lymnaeidae									
Lymnaea sp.									
Viviparidae									
Campeloma sp.									
Viviparus sp.									
Physaeidae									
Physa sp.				43.06					
Amnicolidae									
Amnicola sp.									
Pelecypoda									
Unionidae									
Megalonais gigantia									
Truncilla donaciformis									
T. Truntata									
Lampsila									
Utterbachia imbecilis									
Sphaeridae									
Sphaerium transversum	43.06		43.06		43.06				
S. sulcalum									
Platyhelminthes									
Tubellaria									
Planariidae									
Dugesia trigrina									
Nemathelminthes									
Nematoda									
Diplogasteridae									
Diplogaster sp.						43.06			

Table 13. Benthic Invertebrates collected August 1973.
Values recorded in number per square meter.

SITE: GUTTENBERG C-C'

STATION

	A	B	C	D	E	F	G	H	I
Annelida									
Hirudinea									
Erpbdellidae									
Erpobdella sp.									
Erpobdella puntata									
Nephelopsis obscura									
Glossiphoniidae									
Glossiphonia complanata									
Glossiphonia heteroclita									
Helobdella nepheloidae							43.06		
Helobdella stagnalis									43.06
Placobdella montifera									
Theromyzon occidentale									
Haplotaxidae									
Haplotaxis sp.									
Pisicolidae									
Illinobdella sp.									
Oligochaeta									
Tubificidae									
Branchiura sowerbyi	344.5			43.06	86.12			43.06	
Limnodrilus claparedianus	344.5	43.06		86.12	301.4	172.2			43.06
Limnodrilus hoffmeisteri									
Limnodrilus udekmianus	43.06			43.06	43.06	43.06		43.06	43.06
Peloseolex multisetosus									
Tubifex tubifex	43.06							43.06	
Arthropoda									
Crustacea									
Amphipoda									
Hyallela azteca				129.2	301.4	43.06	43.06		43.06
Isopoda									
Asellus militaris							172.2		43.06
Insecta									
Coleoptera									
Elmidae									
Promoresia sp.									
Chrysomelidae									

SITE: GUTTENBERG

	STATION A	B	C	D	E	F	G	H	I
Donancia sp.									
Diptera									
Ceratopogonidae									
Palpomyia sp.									
Tendipedidae									
Pelopiinae									
Pentaneura sp.	129.2			129.2	172.2		43.06		43.06
Tendipedinae									
Tendipes tentans									
Ephemeroptera									
Baetidae									
Ephedemerella sp.									
Ephemeridae									
Hexagenia limbata	86.12			172.2	86.12	301.4	818.1	43.06	1550.2
Odonata									
Aeschnidae					43.06				
Anax sp.									
Agrionidae									
Agrion sp.									
Libellulidae									
Dorocordulia sp.									
Tricoptera									
Leptoceridae									
Leptocella sp.				43.06					
Leptocerus americanus	43.06			172.2					
Mystacides sp.									
Limnephilidae									
Hesperophylax sp.									
Neophylax sp.						43.06			
Oecetis cinerascens									
Mollusca									
Gastropoda									
Amnicolidae									
Amnicola sp.									
Lymnaeddae									
Lymnaea sp.									

SITE: GUTTENBERG

	STATION									
	A	B	C	D	E	F	G	H	I	J
Pleuroceridae										
Pleurocera acuta			43.06	129.2						
Physaeidae										
Physae sp.				172.2	129.2		129.2			
Menetus sp.										
Valvatidae										
Valvata sp.		43.06		43.06	43.06			43.06	43.06	
Viviparidae										
Campeloma sp.										
Viviparus sp.	43.06	86.12		43.06	43.06	172.2	43.06	172.2	129.8	34.45
Pelecypoda										
Lampsilinae										
Leptodae fragilis	43.06			43.06	86.12			43.08		
Sphaeridae										
Sphaerium transversum	904.3	172.2		430.6	516.7	559.8	172.2	43.06	990.4	172.2
Sphaerium sulcaum	43.06					129.2			86.12	
Unionidae										
Lampsilis higginsil			86.12							
Quadrula nedulata										
Utterdachia imbecilis										
Nemathelminthes										
Nematoda										
Diplogasteridae										
Diplogaster sp.										
Platyhelminthes										
Tubellaria										
Planariidae										
Dugesia tigrina				219.3	516.7		645.9			

SITE: CLAYTON STATION B-B'

	A	B	C	D	E	F
Annelida						
Hirudinea						
Erpbdellidae						
Erpobdella sp.						
Erpobdella puntata						
Nephelopsis obscura						
Glossiphoniidae						
Glossiphonia complanata						
Glossiphonia heteroclita						
Helobdella nepheloidae						
Helobdella stagnalis			172.2	86.12	1,119.5	
Placobdella montifera						
Thermomyzon occidentale						
Haplotaxidae						
Haplotaxis sp.						
Pisicolidae						
Illinobdella sp.						
Oligochaeta						
Tubificidac						
Branchiura sowerbyi						
Limnodrilus claparedianus			86.12	301.4	344.5	
Limnodrilus hoffmeisteri						
Limnodrilus udekmianus						
Peloseolex multisetosus						
Tubifex tubifex				86.12	43.06	
Arthropoda						
Crustacea						
Amphipoda						
Hyallela azteca				172.2		
Isopoda						
Asellus militaris			43.06			
Insecta						
Coleoptera						
Elmidae						
Promoresia sp.						
Chrysomelidae						

SITE: CLAYTON

	STATION					
	A	B	C	D	E	F
Donancia sp.						
Diptera						
Ceratopogonidae						
Palpomyia sp.				129.2	559.8	
Tendipedidae						
Pelopiinae						
Pentaneura sp.			86.12		86.12	
Tendipedinae	86.12	43.06	1,119.5	1,980.8	818.1	
Tendipes tentans						
Ephemeroptera						
Baetidae						
Ephemerella sp.			43.06	86.12		
Ephemeridae						
Hexagenia limbata	430.6	1,464.0	43.06			
Odonata						
Aeschnidae						
Anax sp.						
Agrionidae						
Agrion sp.						
Libellulidae						
Dorocordulia sp.						
Tricoptera						
Leptoceridae						
Leptocella sp.						
Leptocerus americanus						
Mystacides sp.						
Limnephilidae						
Hesperophylax sp.						
Neophylax sp.						
Oecetis cinerascens						
Mollusca						
Gastropoda						
Amnicolidae						
Amnicola sp.						
Lymnaeidae						
Lymnaea sp.						

	STATION					
SITE:	CLAYTON					
	A	B	C	D	E	F
Pleuroceridae						
Pleurocera acuta						
Physaeidae						
Physae sp.						
Menetus sp.						
Valvatidae						
Valvata sp.						
Viviparidae						
Campeloma sp.						
Viviparus sp.						
Pelecypoda						
Lampsilinae						
Leptodae fragilis						
Sphaeridae						
Sphaerium transversum					215.3	
Sphaerium sulcalm						
Unionidae						
Lampsilis higginsil						
Quadrula nedulata	43.06					
Utterdachia imbecilis						
Nemathelminthes						
Nematoda						
Diplogasteridae						
Diplogaster sp.						
Platyhelminthes						
Tubellaria						
Planariidae						
Dugesia tigrina						

SITE: PRAIRIE DU CHIEN STATION Y-Y'

	A	B	C	D	E	F
Annelida						
Hirudinea						
Erpbdellidae						
Erpobdella sp.			129.2			
Erpobdella puntata			43.06			
Nephelopsis obscura						
Glossiphoniidae						
Glossiphonia complanata	43.06					
Glossiphonia heteroclita			43.06	43.06		
Helobdella nepheloidae						
Helobdella stagnalis		645.9	473.7	387.5		
Placobdella montifera						
Theromyzon occidentale			43.06			
Haplotaxidae						
Haplotaxis sp.						
Pisicolidae						
Illinobdella sp.			43.06			
Oligochaeta						
Tubificidae						
Branchiura sowerbyi					43.06	
Limnodrilus claparedianus		129.2	1421.0	43.06	172.2	
Limnodrilus hoffmeisteri						
Limnodrilus udekmianus		43.06	43.06			
Peloseolex multisetosus						
Tubifex tubifex	43.06		43.06		43.06	
Arthropoda						
Crustacea						
Amphipoda						
Hyallela azteca	86.12	215.3	732.0	86.12		
Isopoda						
Asellus militaris	43.06	86.12	1205.7	172.2		
Insecta						
Coleoptera						
Elmidae						
Promoresia sp.						
Chrysomelidae						

	STATION					
SITE:	PRAIRIE DU CHIEN					
	A	B	C	D	E	F
Donancia sp.						
Diptera						
Ceratopogonidae						
Palpomyia sp.						
Tendipedidae						
Pelopiinae						
Pentaneura sp.	172.2			129.2		
Tendipedinae	43.06	86.12	86.12	129.2		
Tendipes tentans						
Ephemeroptera						
Baetidae						
Ephemerella sp.						
Ephemeridae						
Hexagenia limbata	1593.2			172.2	172.2	
Odonata						
Aeschnidae						
Anax sp.						
Agrionidae						
Agrion sp.						
Libellulidae						
Dorocordulia sp.						
Tricoptera						
Leptoceridae						
Leptocella sp.						
Leptocerus americanus						
Mystacides sp.				43.06		
Limnephilidae						
Hesperophylax sp.						
Neophylax sp.						
Oecetis cinerascens			43.06			
Mollusca						
Gastropoda						
Amnicolidae						
Amnicola sp.						
Lymnaeidae						
Lymnaea sp.						

STATION

SITE: PRAIRIE DU CHIEN

	A	B	C	D	E	F
Pleuroceridae						
Pleurocera acùta						
Physaeidae						
Physae sp.						
Menetus sp.				129.2		
Valvatidae						
Valvata sp.		86.12	215.3	43.06		
Viviparidae						
Campeloma sp.	43.06					
Viviparus sp.	172.2					
Pelecypoda						
Lampsilinae						
Leptodae fragilis						
Sphaeridae						
Sphaerium transversum	861.2				689.0	
Sphaerium sulcalm						
Unionidae						
Lampsilis higginsil						
Quadrula nedulata						
Utterdachia imbecilis						
Nemathelminthes						
Nematoda						
Diplogasteridae						
Diplogaster sp.						
Platyhelminthes						
Tubellaria						
Planariidae						
Dugesia tigrina	43.06			43.06		

SITE: LYNXVILLE A-A'

	STATION					
	A	B	C	D	E	F
Annelida						
Hirudinea						
Erpbdellidae						
Erpobdella sp.						
Erpobdella puntata						
Nephelopsis obscura						
Glossiphoniidae						
Glossiphonia complanata						
Glossiphonia heteroclita						
Helobdella nepheloidae						
Helobdella stagnalis						215.3
Placobdella montifera						
Theromyzon occidentale						
Haplotaxidae						
Haplotaxis sp.						
Pisicolidae						
Illinobdella sp.						
Oligochaeta						
Tubificidae						
Branchiura sowerbyi				43.06		
Limnodrilus claparedianus		258.4	387.5	2928.1	86.12	43,318.4
Limnodrilus hoffmeisteri						
Limnodrilus udekmianus				215.3		1,851.6
Peloseolex multisetosus						
Tubifex tubifex				172.2		215.3
Arthropoda						
Crustacea						
Amphipoda						
Hyallela azteca						
Isopoda						
Asellus militaris						
Insecta						
Coleoptera						
Elmidae						
[illegible]resia sp.						
[illegible]somelidae						

SITE: LYNXVILLE

	STATION					
	A	B	C	D	E	F
Donancia sp.						
Diptera						
Ceratopogonidae						
Palpomyia sp.		43.06				43.06
Tendipedidae						
Pelopiinae						
Pentaneura sp.				301.4		
Tendipedinae						
Tendipes tentans			516.7	215.5		172.2
Ephemeroptera						
Baetidae						
Ephemerella sp.						
Ephemeridae						
Hexagenia limbata	861.2					
Odonata						
Aeschnidae						
Anax sp.						
Agrionidae						
Agrion sp.						
Libellulidae						
Dorocordulia sp.						
Tricoptera						
Leptoceridae						
Leptocella sp.						
Leptocerus americanus						
Mystacides sp.						
Limnephilidae						
Hesperophylax sp.						
Neophylax sp.						
Oecetis cinerascens						
Mollusca						
Gastropoda						
Amnicolidae						
Amnicola sp.						
Lymnaeidae						
Lymnaea sp.						

SITE: LYNXVILLE

	STATION A	B	C	D	E	F
Pleuroceridae						
Pleurocera acuta						
Physaeidae						
Physae sp.						
Menetus sp.						
Valvatidae						
Valvata sp.						
Viviparidae						
Campeloma sp.						
Viviparus sp.						
Pelecypoda						
Lampsilinae						
Leptodae fragilis						
Sphaeridae						
Sphaerium transversum	172.2					
Sphaerium sulcalm						
Unionidae						
Lampsilis higginsil						
Quadrula nedulata						
Utterdachia imbecilis						
Nemathelminthes						
Nematoda						
Diplogasteridae						
Diplogaster sp.						
Platyhelminthes						
Tubellaria						
Planariidae						
Dugesia tigrina						

this season. The finger nail clams, Sphaerium are primarily found in the lower part of the pool, at Transect C-C'. Extensive populations of these clams were found on exposed mud flats in transect A-A' where they died when the high waters of the spring floods receeded. The abundance of the tubificidae, and the isopod Asellus, commonly associated with pollution, seem to be correlated with the abundant layers of organic silt which covers the bottom of almost all of the back water sites. This is especially true at the A-A' transect where a silt accumulation of 1.9 feet has occured since formation of Dam #9 (Figure 18).

AQUATIC MACROPHYTES

The aquatic macrophytes, both emergent and submerged (Table 14 and 15) show similar patterns to that found in the benthic invertebrates. The two lower transects C-C'; and B-B' have several diverse stands of submerged aquatics. The stands are found in transect C-C' on the submerged islands which rise within 2 feet of the surface. At the B-B' transect the extensive areas in the inner backwater sloughs are dominated by a diverse community including; wild rice, coontail, white water lily, and the duck weeds. Sago pondweed and Potomogeton nodosus are abundant in many of the stands. Only one site at the Y-Y' transect supported submerged aquatics at the time of our sampling due to the low water level, however a week later the extensive mud flats of emergents were covered with a foot and a half of water and had a limited community of submerged aquatics. If this type of fluctuation is typical, it may account for the lowered diversity at this transect. There were no stands of submerged aquatics at the A-A' transect, the excessive siltation apparently has prevented the development of this

Figure 18. Bottom profiles of Northern Transect.

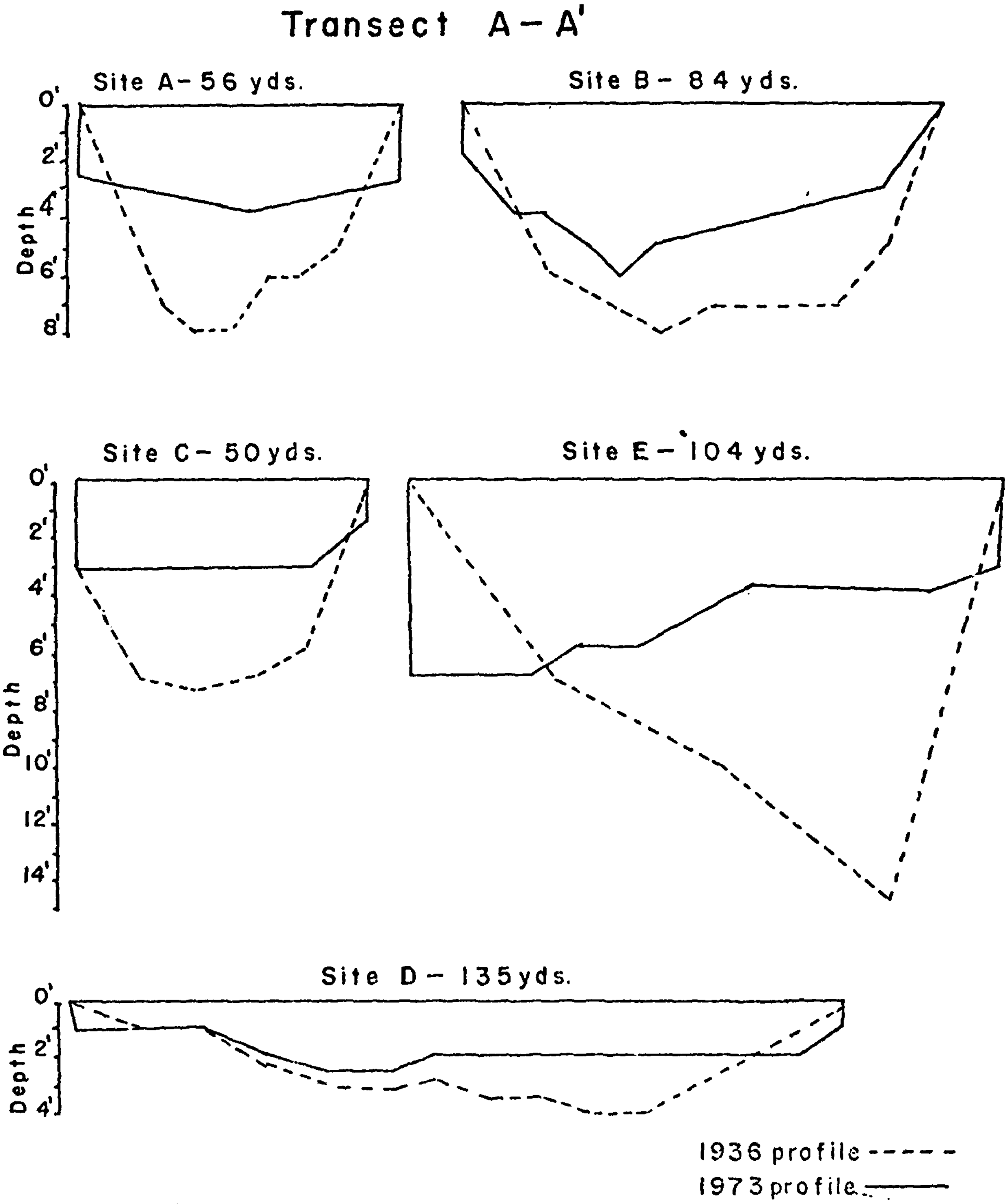


Table 14.

Emergent Aquatic Communities

	Clayton D East	D Center	E	E	Prairie du Chien A-B	A-B	Lynxville I-A	E-F
Bidens beckii						10		
Carex sp.							20	
Cephalzenthus occidentalis				P	10			
Juncus juncus		10					100	
Leersia oryzoides	100			90	90			
Lemna minor		80	100	30	100	100		
Polygonum coccineum							20	40
Pontederia cordata	P	20						
Sagittaria graminea	10	100	100					
Sagittaria latifolia		40	100	50	100	100	100	100
Scirpus fluviatilus				60	10	100		
Sparganium eurycarpum				70				100
Spirodella polyrhiza		80	100	30	100	100		
Typha angustifolia				60				
Wolffia columbiana			100					
Zizania		90						

Table 15.

Submerged Aquatic Communities

	Guttenberg				Clayton						Prairie du Chien
	A	B	C	D	C	D	E_1	E_2	E_3	E_4	D
Brasenia schreberi	P		14			30					
Ceratophylum demersum	10	40	43	50	78	80	75		50	100	80
Elodea canadensis	2						25				
Heteranthera dubia	7	30	78	83	4		100		25	50	20
Leeria oryzoides								25			
Lemna minor	3			67	56	100	100	100	100	25	30
Nelumbo lutea	10	90	14		17			75		50	20
Nymphaea odorata						20			25		
Ntmphaea tuberosa	3				56	90	100	25	100		
Potomogeton crispus	P	40	43	17	26						
Potomogeton foliosus	5					30	50			25	100
Potomogeton illinoensis	2										
Potomogeton nodosus	15	60	78	100	13			50	50	50	10
Potomogeton pectinatus	28	40	43	67	4	70				100	30
Sagittaria graminea								100			
Sagittaria latifolia				33				100			
Spirodela polyrhiza	2		36	67	56	100	100	100	100	25	50
Utricularia vulgaris							50				
Vallisneria americana	63	30	14								30
Wolffia columbiana							100	100	100		

Table 16. Stand Characteristics Bottom land and Woodland

Site: Clayton

Stand #	II				III					IV					V				
*Stand characteristics	I.V.	a	b	c	I.V.	a	b	c	d	I.V.	a.	b	c	d	I.V.	a	b	c	d
Acer saccharinum	191	150	203	77	100	12		9	17	127	25	32	29	20	50	9	31	8	
Betula nigra					5				1	29			5	7	23			15	
Carya Cordiformis						1													
Celtis occidentalis					7	8	2			5	4	5							
Fraxinus pennsylvania		6			14	13	4	1		25	1	2	10	2	30	2		15	
Gleditsia triacanthos																			
Gymocladus dioica					11		4	2											
Morus rubra						1													
Populus deltoides	10			10															
Quercus alba					6				1										
Quercus bicolor					59	5	7	5	6	42		7	17	2		18			
Quercus macrocarpa					4		1												
Salix amygdaloides																			
Salix nigra	19			19															
Ulmus americana	78	66	58	19	94	23	11	12	11	72	15	27	27	2	197	61	192	45	
Density trees/acre	388				96					197					306				
Density saplings/acre	222				62					45					90				

*Stand characteristics
- I.V. = Importance value
- a = density of saplings, stems/acre
- b = density of trees 12" - 80" Basal Area stems/acre
- c = density of trees 81" - 320" Basal Area stems/acre
- d = density of trees 321" + Basal Area stems/acre

Table 16 (continued)

Site:	Guttenberg					Prairie du Chien														
Stand #	I					VI					VII					VIII				
	I.V.	a	b	c	d	I.V	a	b	c	d	I.V.	a	b	c	d	I.V.	a	b	c	d
Acer saccharinum	130	6	16	44		209	29	113	51	24		10					86			
Betula nigra						10	8	7	4							143	101	80	28	
Carya Cordiformis		2																		
Celtis occidentalis																				
Fraxinus pennsylvania	48	1	24	4		43	28	32	11		45	5		13		11	8		5	
Gleditsia triacanthos																44	8	9	14	
Gymocladus dioica																				
Morus rubra																				
Populus deltoides																13				9
Quercus alba																				
Quercus bicolor	38	2	12	8																
Quercus macrocarpa																				
Salix amygdaloides						4		4			224	14	109	25	42					
Salix nigra							2				30	1	17			9		5		
Ulmus americana	83		12	20	4	33	63	43								79	8	27	11	17
Density trees/acre	146					289										188				
Density saplings/acre	11					129										311				

Table 16 (continued)

Site: Lynxville

Stand #	IX					X					XI					XII				
	I.V.	a	b	c	d	I.V.	a	b	c	d	I.V.	a	b	c	d	I.V.	a.	b.	c.	d.
Acer saccharinum	171	7	26	49	15	152	7	14	14	55	168	2	40	82	12	105	14	25	19	32
Betula nigra	6			2		28			15	3	12			6		24		3	3	8
Carya Cordiformis																				
Celtis occidentalis																				
Fraxinus pennsylvania	51	1	8	11	4	18			12		29		18	6		28	4	6	11	3
Gleditisia triacanthos																				
Gymocladus dioica																				
Morus rubra																				
Populus deltoides	17				2															
Quercus alba																				
Quercus bicolor																16		3		3
Quercus macrocarpa																				
Salix amygdaloides																				
Salix nigra		1																		
Ulmus americana	55	16	68	62	21	102	95	111	10		92	14	41	24	6	128	89	92	8	16
Densit, trees/acres	151					235					233					221				
Density saplings/acre	16					102					16					107				

community. The steep banks in this region also limited the emergent community to narrow bands along the waters edge.

The initial increase in emergent vegetation described by Green (1947) has not persisted in the northern reaches of Pool 10, and at present seems to be restricted to the lower 1/3 of the pool from the Clayton-Bagley area south to Dam #10.

TERRESTRIAL VEGETATION

The terrestrial community is primarily composed of wet mesic stands dominated by silver maple or elm. (Table 16). They occur on the raised levees or islands above the normal pool level. The density of trees averages 218 trees/acre and the saplings average 95 saplings/acre. The great similarity of the stands is shown by the ordination based of the index of similarity $\frac{2w}{a + 6}$ (Beals, 1960, Bray J. and Curtis, 1957) (Figure 19). The river birch and swamp white oak typical of the upland border is found only at the western edge of the Y-Y' transect, this type has been eliminated in many areas due to the agricultural and industrial development of the first terraces. The development of the willow-cottonwood type is restricted since the regulation of the pool has eliminated the periods of low water during the summer which normally is required for the initiation of reproduction, especially the cottonwood. (Lindsey, et. al. 1963). This lack of low water may also be a factor in the poor reproduction in the wet mesic woodlands. The low sapling populations would limit the recovery of these stands from any reduction in the overstory. The prevalence of dutch elm descase in the general area poses a particular threat, especially since elm is the dominant sapling in the majority of the stands.

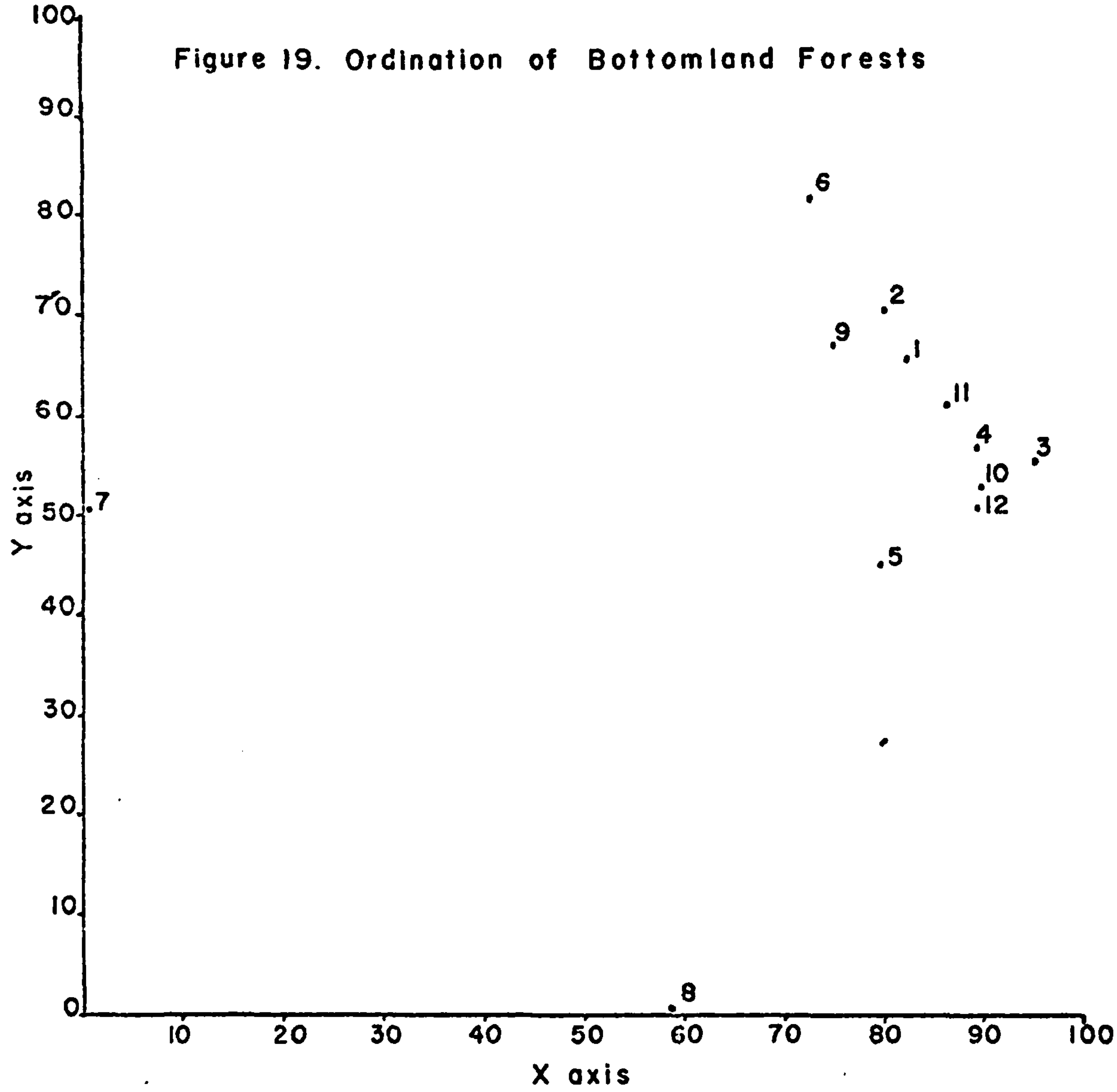


Figure 19. Ordination of Bottomland Forests

It was not possible to calculate the coverage of the various stand types in Pool 10 since only a limited portion of woodlands of the pool have been plotted and identified in the resource management plan, and recent aerial photos of the normal pool were not available to plot the data. The understory was limited, especially in the northern section of the pool. The species with a presence of over 50% are Leersia virginica, Menispermum canadense, Rhus radicans, and Viola sp. The lack of understory in the A-A' transects and the low density or absence of Rhus radicans in the Y-Y' and A-A' transects were noted. Since there was an extended period of high water in 1973 it is difficult to decide if this lack of understory is atypical, and a result of the particular conditions this year, or if this is the basic pattern. If it is, it would be interesting to evaluate if this also is a result of the maintainance of water levels, with the elimination of the lowered levels of the late summer. (Table 17)

The absence of previous data to use in comparison limits the conclusions which are possible in the present study. However future studies, using this data base should be able to evaluate some of these problems.

Table 17. Herbaceous Frequency in Woodland Stands Along Transects.

	Prairie du Chien			Clayton			Guttenberg	
	VI	VII	IX	II	III	IV	V	I
Arisaema dracontium				10%	30%	P		10%
Asclepias incarnata			10%					
Asparagus officinalis			P					
Bidens sp.	P	10%						
Bidens coronata						30%		
Bidens vulgata				P	10%			
Carex sp.	P		90%					
Cuscuta sp.					30%	40%		
Echinocystis lobata	P							
Geranium maculatum			20%					
Hedeoma pulegiodes			40%					
Iris virginica		10%	40%					
Laportea canadensis			10%		60%	70%	40%	30%
Leersia virginica	P	100%		30%	50%	80%	90%	30%
Lonicera dioica			10%					10%
Lysimachi celiata			100%					
Menispermum	P		60%	P	80%	20%		100%
Onoclea sensibilis					10%	P		
Parthenocissus inserta			10%	20%				
Pilea pumila		40%			30%	60%		
Polygonum coccineum	P	30%			30%			
Phus radican			10%	20%	60%	70%	50%	50%
Smilax herbacea					20%	40%		10%
Smilax hispida				20%				
Solidago gigantea	P	100%	10%		30%	10%		
Sagittaria latifolia		20%						
Thalictrum				P				
Viola sp.	P		10%	10%	10%		50%	10%
Vitis vulpina	P		30%	50%	10%			
Xanthium strumarium	P							

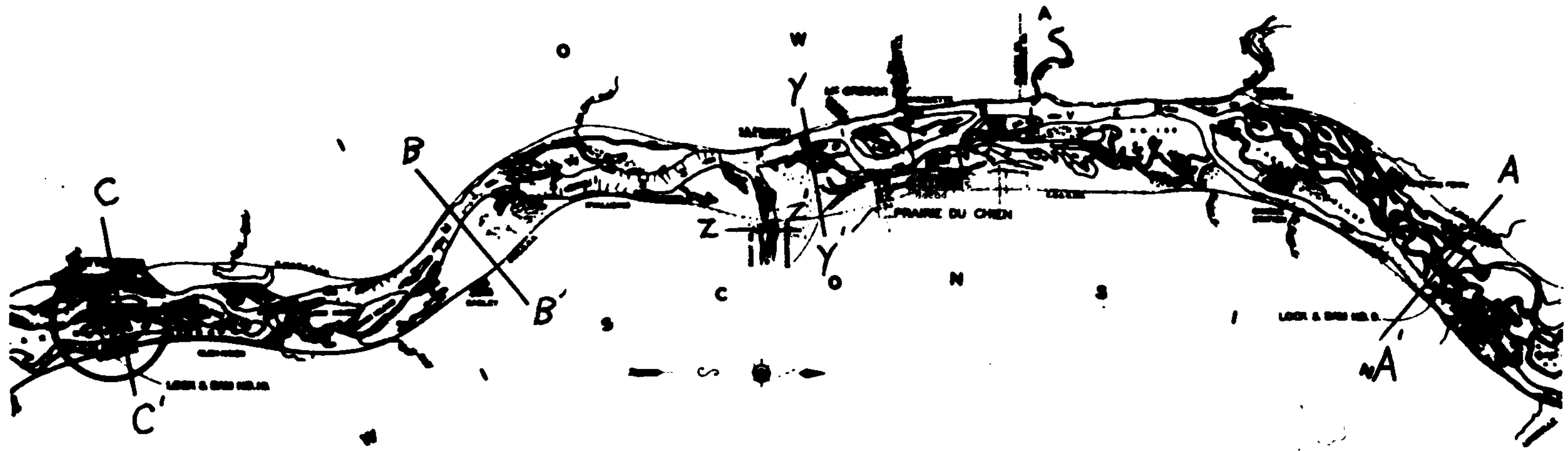


FIGURE 20

Figure 21. Stand locations, Transect A-A'

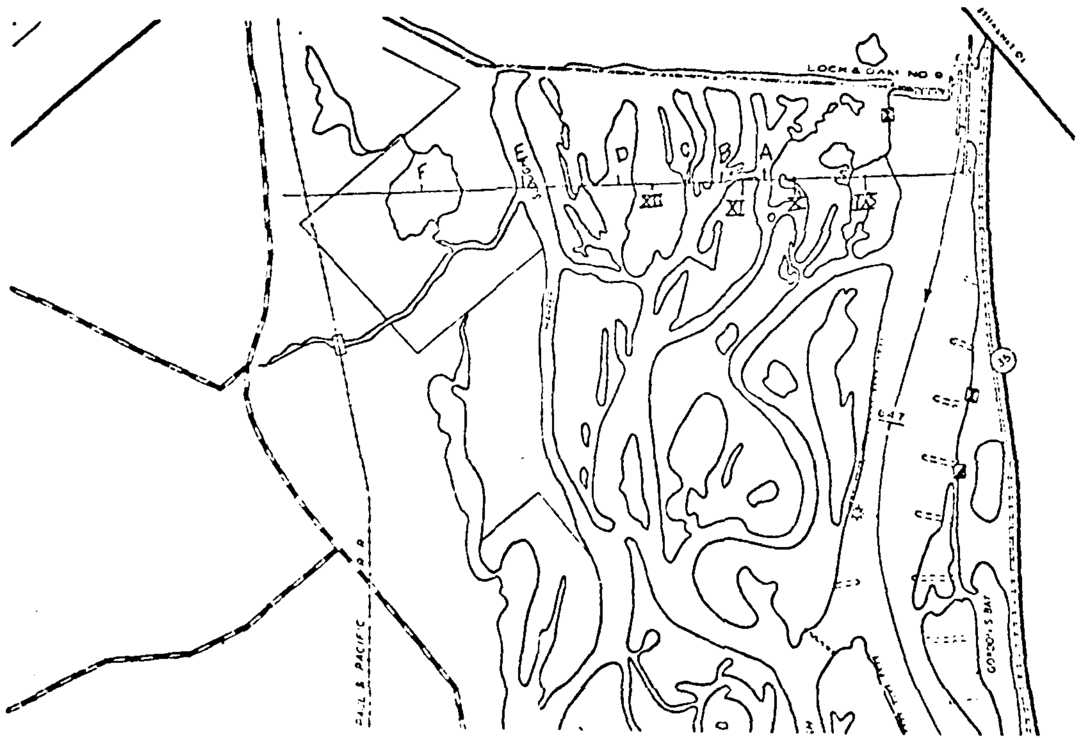
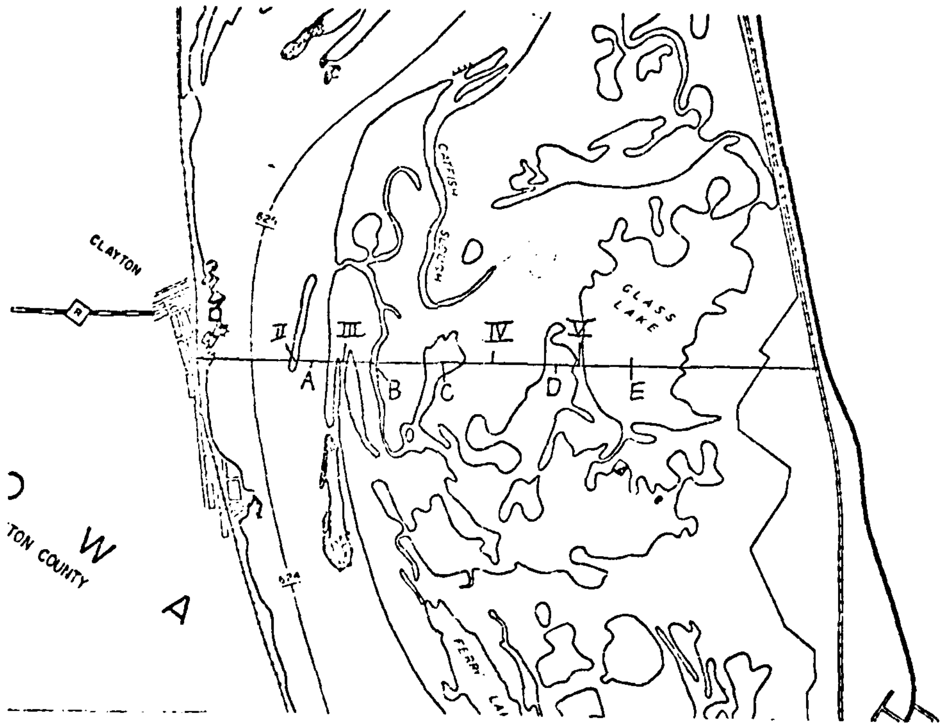


Figure 22. Stand locations, Transect B-B'



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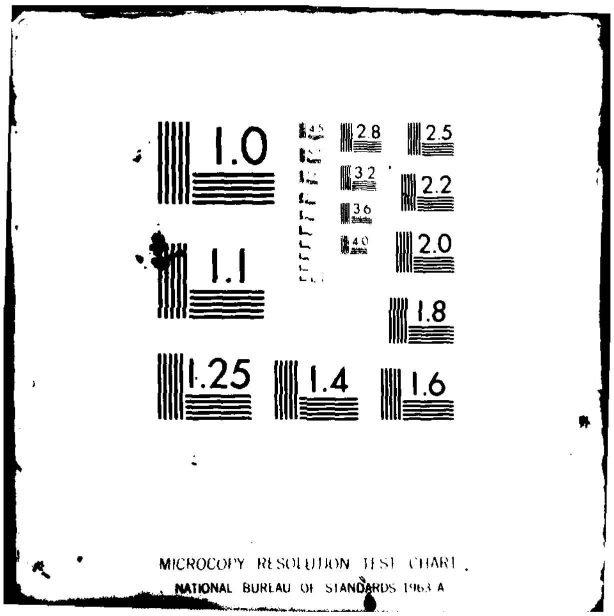
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Figure 23. Stand locations, Transect C-C'

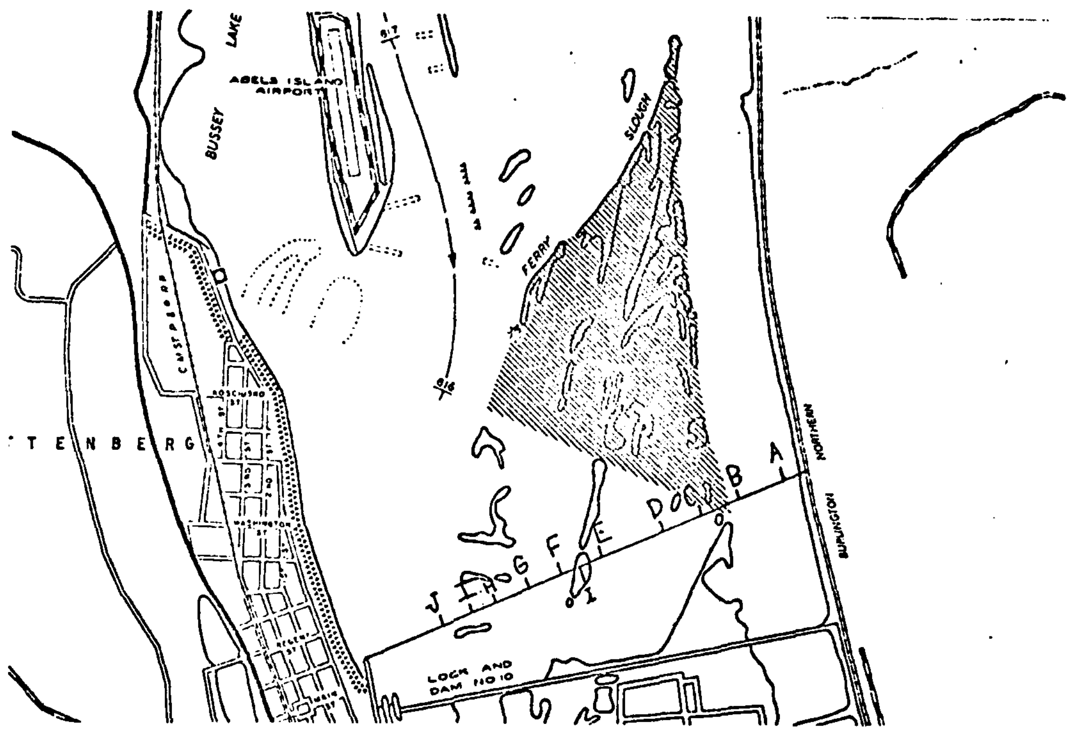
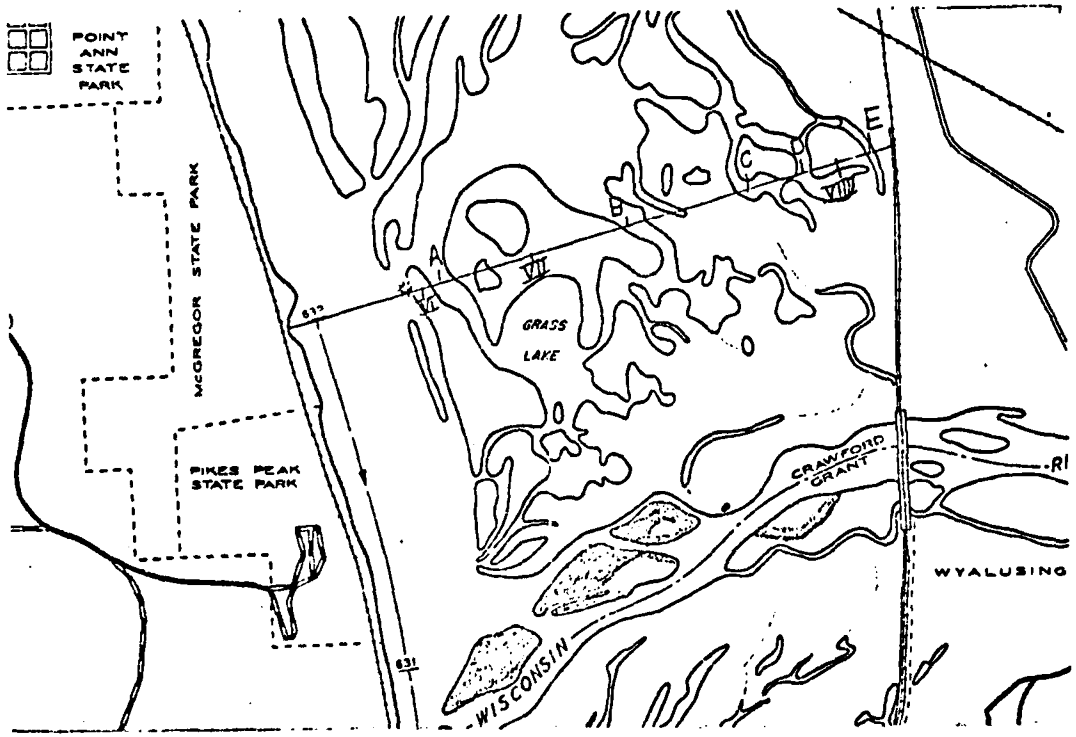


Figure 24. Stand 1 cations, Transect Y-Y'



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10. APPENDIX B: ARCHAEOLOGICAL BACKGROUND INFROMATION

10. APPENDIX B: ARCHAEOLOGICAL BACKGROUND INFORMATION

Archaeological and historic sites of importance consist of such diverse elements as prehistoric village sites, petroglyphs (rock pictures), burial mounds, log cabins, forts, and so forth. Sites of significance may date from thousands of years ago to very recent times. Interest in studying elements of human history also varies as much with the times as interest in studying elements of natural history.

STUDIES IN THE LATE 1800's: THE LEWIS AND HILL SURVEY

Fortunately for our study now there was a strong interest in the late 19th Century in burial mounds; a massive study was pursued for approximately 20 years by Alfred J. Hill and Theodore H. Lewis. The extent of their work is best understood by examining a few of their manuscripts, a few samples of which are reproduced in this report. In 1928, Charles R. Keyes wrote of their accomplishments:

> "The great extent of the archeological survey work accomplished by Lewis and Hill cannot be appreciated except through an extended examination of the large mass of manuscript material that has been preserved. This consists approximately of the following forty leather-bound field notebooks well filled with the original entries of the survey; about a hundred plats of mound groups drawn on a scale of one foot to two thousand; about eight hundred plats of effigy mounds (animal-shaped mounds from Minnesota, Wisconsin, Iowa, and Illinois) on a scale of one foot to two hundred; about fifty plats of "forts" (largely village sites of the Mandan type) and other inclosures on a scale of one foot to four hundred; about a hundred large, folded tissue-paper sheets of original, full-size petroglyph rubbings with from one to six or more petroglyphs on each; about a thousand personal letters of Lewis to Hill; four bound "Mound Record" books made by Hill and in his handwriting; eight large, well filled scrapbooks of clippings on archeological matters made by Lewis; numerous account books, vouchers, and other miscellany...

"A single sheet of summary found among the miscellaneous papers of the survey, apparently made by Lewis, is eloquent in its significance. Tabulated by years and place of entry the mounds alone that were actually surveyed reach a grand total of over thirteen thousand--to be exact, 855 effigy mounds and 12,232 round mounds and linears...

"The survey is quite full for Minnesota, where work was done in all but three counties of the state, resulting in records of 7,773 mounds, besides a number of inclosures... much information was also gathered from the river counties of Iowa, Nebraska, Kansas, and Missouri. In Wisconsin the survey touched more than two-thirds of all the counties, mostly in the field of the effigy mounds in the southern half of the state, where the records supply detail for no less than 748 effigies and 2,837 other mounds. Iowa was explored most fully in the northeastern counties as far south as Dubuque, yielding data on 61 effigy mounds, 553 other mounds, and several inclosures, ...the survey yielded its richest results in Minnesota, the eastern parts of the Dakotas, northeastern Iowa, and the southern half of Wisconsin..." (Surveys were also conducted in the Dakotas, Manitoba, Missouri, Nebraska, Kansas, Illinois, Indiana, and Michigan--in all, eighteen states.)

"The strength of the survey consists, first of all, in the dependability of Lewis as a gatherer of facts... he worked as a realist, measuring and recording what he saw with painstaking accuracy and unwearying devotion... And the fact that these surveys were made at a time when a large number of mound groups that have since disappeared, or all but disappeared, were still intact, gives the work of Lewis and Hill an incalculable worth... So far as Iowa is concerned, something like half of the antiquities of the northeastern part of the state are recoverable only from the manuscripts of the Northwestern Archeological Survey..."

A typical description of the reporting format followed by Lewis and Hill is reprodeuced here:

(IN: MOUNDS IN DAKOTA, MINNESOTA AND WISCONSIN)

3. OTHER MOUNDS IN RAMSEY COUNTY, MINNESOTA.

At the lower end of the Pig's Eye marsh already mentioned, there stood (April, 1868) an isolated mound, not situated on the bluffs, but below them, near their foot, at the highest part if the river bottom on the sloping ground half-way between

> the military road and the road-bed of the St. P. & C. R. R., then in course of construction, and distant about three hundred and fifty feet southward from the culvert on the former. It was in a cultivated field, and had itself been plowed over for years; yet it had still a mean height of six and a half feet; its diameter was sixty-five feet. The top of it was only thirty-one feet above the highwater of the Mississippi, according to the levels taken by the railroad engineers. The location of the mound, according to U. S. surveys, was on the N. 1/2 of SE. 1/4 of Sec. 23, T. 28, R. 22, and about one mile north of Red Rock landing. Mr. J. Ford, one of the old settlers of the neighborhood, said that a man named Odell had, some years previously, dug into it far enough to satisfy his curiosity, as the discovery of human bones clearly proved it to have been built for sepulchral purposes.
>
> 7. MOUNDS AT PRESCOTT, WISCONSIN.
>
> At the angle formed by the confluence of the St. Croix and Mississippi rivers, on the eastern bank of the former, is the town of Prescott, Wisconsin. On May 13, 1873, three hours' time was employed in making such reconnaissance survey as was feasible of the mounds which stretch along the bluff on the Mississippi there. The smallest of them was about twenty-five feet diameter and one foot high, and the largest fifty-six feet diameter and four feet high, as nearly as could be then ascertained.

Pictographs were common on caves along the Mississippi River bluffs. Lewis and Hill recorded their locations and frequently the pictures themselves. Although specific reference was made to them in Houston, Winona, Washington, and Ramsey counties in Minnesota and Alamakee and Clayton counties in Iowa, it would be unwise to assume that they were limited to these locations.

Captain Carver, in 1766-67 explored a cave (in present day Ramsey County) as being of "amazing depth and containing many Indian hieroglyphics appearing very ancient." The cave, called by the Dakota "Wakan-teebe", became a popular tourist attraction in the 1860's. Railroad construction was responsible for its destruction by the 1880's.

PRESENT CONSIDERATIONS

The difficulty, then, is not the absence of records of significant sites, but rather that records of thousands of sites exist. And although archaeologists have resurveyed some of the sited, vast areas have not been checked since the original surveys. The farmer, in the course of clearing and farming his land, is chiefly responsible for the destruction of the sites, and most of the sites have by now been destroyed.

WISCONSIN

Early Archaeology

Increase A. Lapham recorded the results of Wisconsin archaeological research which he began in 1836 in The Antiquities of Wisconsin, published in 1850. Although his work was extensive and continued until his death in 1875, if focused on areas other than the Mississippi River Valley. He described sites along the Mississippi River as far north as the La Crosse River; then concluded: "Only an occasional mound was observed along the valley of the La Crosse River; and it is believed that no works of any considerable extent exist above this point on the Mississippi." See Figure 1.

A review of the publications of Lapham, Robert Ritzenthaler, and Charles E. Brown reveal that Wisconsin archaeological and historic sites, especially burial mounds, were extensive.. The number of mounds in Wisconsin were estimated to number 15,000. Sites occurred on and near the shores on nearly every stream and lake. In addition to burial mounds, "sites of native villages, camps and workshops; plots of corn hills and garden beds; enclosures; burial places and cemeteries; refuse heaps and pits; cave shelters; shrines; pictograph rocks; boulder mortars, sources of flint, quartz, quartzite and pipestone; lead diggings; copper mining pits; stone heaps and circles; cairns; and trails" are of interest to the Wisconsin archaeologist. Burial mounds, village sites, forts, and pictographs are found in the Mississippi River Valley. See Figure 2.

Recent Archaeology

An important discovery was made in 1945 by two Mississippi River fisher-

men who "saw some aritfacts projecting from the bank which had been undercut by the action of the River." The "Osceola Site" in Grant County is located two miles south of Potosi on the Mississippi River bank. (NW 1/4 of Sec. 14 T.2, N. Range 3, W. of 4th Principal Meridian). Excavation of the burial mound revealed copper implements, as well as projectile points and banner stones. The copper implements provide evidence of the presence of Indians belonging to the "Old Copper Culture" who probably arrived in the State about 3000 B. C.

The site had been damaged, however, by rising river water. Ritzenthaler who described the site in 1946 stated:

> Up to 8 years ago this was the bank of the Grand River, but the installation of a dam at Dubuque raised the water and widened the Mississippi at this point. . . . Test pits revealed that the burial pit extended about 70 feet along the bank, and was about 20 feet wide at this time, but it must have been considerably wider originally judging from the amount of material washed into the river.

No mention was made abcut intended future disposition of the site. Ritzenthaler also mentioned that another site, Raisbeck, in Grant County had been excavated, but he did not give an exact location. Other mounds were located on the Mississippi River bluffs above Potosi and were mentioned in the 1927 edition of Scenic and Historic Wisconsin.

Dr. Freeman stated that an extensive survey of sites was conducted in Crawford County when the St. Feriole Island buildings were recommended for inclusion in the National Register of Historic Places. St. Feriole Island was originally a prairie between the Mississippi River and the bluffs of Prairie du Chien. It contained many burial mounds which were not effigy shaped.

An article in 1853 by Lapham stated that the mounds "are so near the river that their bases are often washed by floods." During the highest known flood--1826--only the mounds could be seen above the surface of the water. The first fort was built on an Indian mound, as were several French homes. Lapham stated that the mound was excavated but that no remains were found in it. He did note some remains of an "American fort taken by the British in the War of 1812." Lapham, in visiting the mounds in 1852, found them "almost entirely obliterated due to cultivation and the light sandy nature of the materials."

In Pepin County, Ritzenthaler reported the existence of an Indian Village site, 2 miles east of Pepin, along a wide terrace to the Mississippi. Pepin is also mentioned as the site of French forts including St. Antoine, built in 1686, above the mouth of Bogus Creek. In Trempealeau County, Nicolls Mound, the Schwert Mounds, and the Trowbridge site have been excavated. Perrot State Park in Trepealeau contains Indian mounds and the site of a log fort erected by N. Perrot, a French explorer, in 1685-6. Indian mounds are also preserved in La Crosse.

In an article published in 1950, "Wisconsin Petroglyphs and Pictographs" Ritzenthaler enumerated the existence of the following petrographs. He did not specify their exact location. Their condition had been unchecked since 1929. Exact location and current condition should be checked with the state archaeologist. In Vernon, La Crosse, Crawford, and Trepealeau Counties, sandstone and limestone cliffs and caves with petrographs were recorded. Larson Cave in Vernon County contained petroglyphs described as being in

excellent condition in 1929, Samual's Cave, La Crosse County, containing petroglyphs and pictographs was first investigated in 1879--and was still in excellent condition in 1929. Galesbluff, La Crosse County, contained petroglyphs carved on soft limestone. Nearly all of the petroglyphs in Trempealeau County in the Trempealeau and Galesville rock shelters have been destroyed--either by road builders, erosion, or tourists. Pictographs were described by L. H. Bunnel in 1897, "a short distance above Praire du Chien." Ritzenthaler did not report their present condition.

Future Studies

Dr. Freeman mentioned specific sites which have been flooded are located on Lake Pepin, at Trempealeau, and at Wyalusing. In the limited time available, this author could not locate any current publication describing the extent or present condition of sites known to have existed in Wisconsin. The Wisconsin Archaeologist, if reviewed issue by issue, would reveal considerably more data on the above mentioned sites, as well as other, perhaps more important, sites. However, lack of time precluded that examination. An examination of that publication, a review of the files in the historical society, and on-site visits would be required before one could be assured of an accurate analysis of the present condition of the sites.

National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive indexing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture.

The Register is an official statement of properties which merit preservation.

The only Wisconsin archaeological or historic bordering the Mississippi or St. Croix rivers listed in the Register is in Crawford County on St. Feriole Island in the Mississippi River, at Prairie du Chien.

Astor Fur Warehouse, Brisbois House, Dousman Hotel, Second Fort Crawford, Villa Louis

All of the above structures are remains of the early establishment of Prairie du Chien as an early fur trade, steamship, and railraod center. They were constructed between 1808 and 1864 and most are still under private ownership.

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According to Marshall McKusick, Iowa State Archaeologist, there were perhaps 30,000 Indian burial mounds in Iowa. Most of them lay on prominent ridges or bluffs along all of the rivers and larger streams. The mounds occur in clusters or groups; a single site sometimes contains more than 100 mounds. Mounds are in three forms: conical (round), linear(long), and effigy. The effigy mounds are large, elaborately shaped animal forms which may measure as many as 100 feet across.

Early Survey Work

The original survey work on Iowa mounds was conducted in the late 19th Century by Lewis and Hill. Records detail legal location by township, range, and 1/16 sections; thus locations are recorded to the nearest 40 acres. Nearly all of the sites have subsequently been destroyed by farming.

In Alamakee and Clayton Counties, 132 and 44 archaeological sites respectively have been surveyed. These sites contain effigy mounds which were built along the Mississippi River bluffs and on the river flats. The Effigy Mounds National Monument in Alamakee County, just north of McGregor has been created to preserve the effigy mounds on the Mississippi River bluffs. Only by checking the site locations filed in the Archaeological Laboratory, University of Iowa, Iowa City, and by on-site inspections could we determine exactly how many sites are or were found along the river flats (and thus subject to damage by the Corps of Engineers).

Charles R. Keyes, in an article about the Hill-Lewis archaeological survey (1928) wrote:

> ". . . Lewis visited on May 4, 1892, the 'prairie,' or terrace, on which stood the village of Harper's Ferry in Alamakee County, Iowa. This area is rather level and extends along one of the secondary channels of the Mississippi for about three miles, with a width between the river and the bluffs of from half a mile to a mile. He found nearly all of the terrace under cultivation and made an actual survey of only five mounds, four bear effigies and one conical mound. He did, however, make a count of mounds still discernible and he entered his count in a penciled note: This group consisted of 107 tailless animals (s) (probably bear mounds), 67 birds, 98 embankments that were probably animals, 154 embankments (linear mounds) and 240 round mounds the largest of which is now about 6 feet high. Total number of effigies in sight including surveyed, 671. Add 229 small round mounds (estimated) that have been destroyed by cultivation makes a total of 900 mounds of all classes. This note may be the record of the largest mound group ever erected by the prehistoric inhabitants of America. On August 20, 1927, the writer walked over the entire extent of this terrace and was able to count only eighteen mounds, a few even of these rather doubtful. The soil of the terrace is quite sandy, and once deprived of their covering of vegetation and put under the plow the mounds disappear in a few years."

Recent Studies

McKusick reports that very little substantial excavation of Iowa effigy mounds has been completed. He mentions in Men of Ancient Iowa that Ellison Orr excavated a bear effigy mound which is part of a group known as Brazells Island Mound Group, located on an island in the Mississippi River opposite Harper's Ferry in Alamakee County. More recently excavations were conducted in the Sny Magill Mound Group in Clayton County and in Mound 2 of the Harvey Island Mound Group, also in Clayton County. Petroglyphs (rock carvings) were found by Lewis and Hill on the sides of rocky outcrops which are most common along the Mississippi River bluffs in Alamakee and Clayton counties. Sites

mentioned by Lewis and Hill and later rechecked by Ellison Orr were found to have weathered badly, or to have disappeared entirely (due to their being on sandstone). Rock slides protected a few sites by sealing them off and thus preventing weathering.

Future Studies Needed

McKusick mentions other archaeological sites found in Iowa: camps, villages, forts, cemeteries, fish dams, and rock quarries. Individual site records would have to be checked and on-site visits made to determine which sites were located along the Mississippi and whether or not Corps of Engineers activity specifically affected any of them.

National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive indexing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture. The Register is an official statement of properties which merit preservation. The only site on the river in Iowa listed in the Register is:

Effigy Mounds National Monument - located in Alamakee and Clayton Counties, three miles north of Marquette, Iowa. The National Monument preserves traces of Indians living there about 1000 years ago. It is an area of 1,467 acres divided by the Yellow River which flows into the Mississippi. It is most significant for its effigy mounds which provide information on the burial customs of prehistoric and historic Indians. Further information on the area is found in the Iowa report.

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